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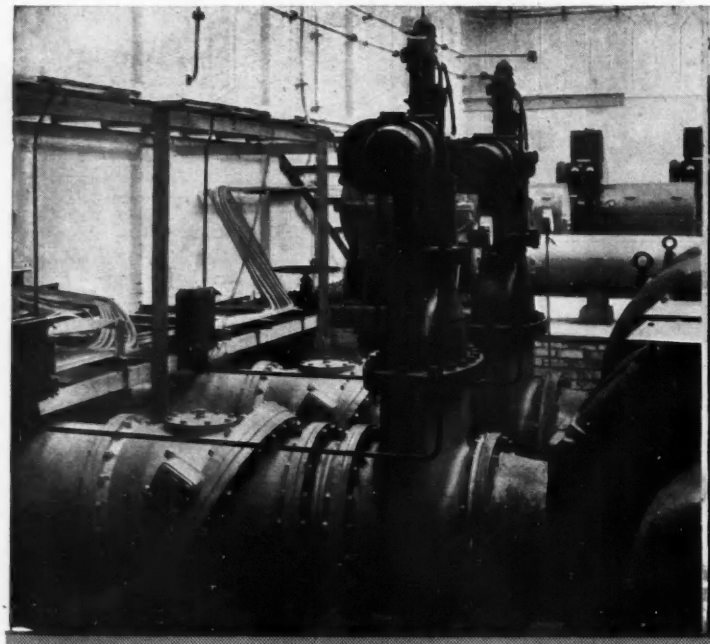

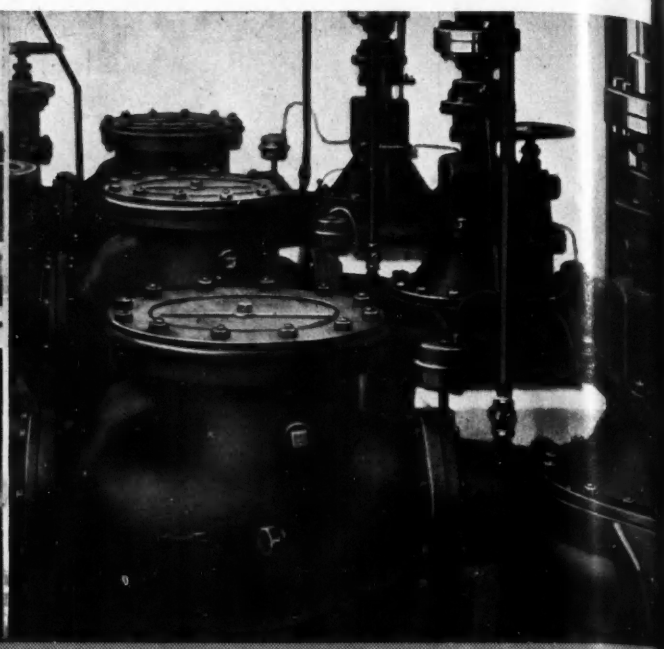

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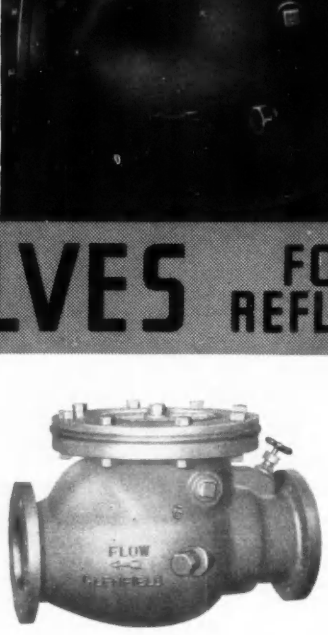

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The Institution of Mechanical Engineers

As announced some weeks ago, Sir Henry Guy, C.B.E., D.Sc., F.R.S., will retire from the secretaryship of the Institution of Mechanical Engineers at the end of December. At a special meeting of the Institution to-night the Council will recommend that Mr. Brian G. Robbins, M.Sc. (Eng.), A.C.G.I., M.I.Mech.E., be appointed by the corporate members as secretary as from January 1st next. Mr. Robbins, it will be remembered, was secretary of the Institution of Automobile Engineers, and when that Institution amalgamated with the Institution of Mechanical Engineers he continued as an assistant secretary to deal with the affairs of the Automobile Division.

Training Course for Agricultural Engineers

A NEW department for the training of agricultural engineers was opened at the College of Aeronautical and Automobile Engineering at Chelsea last week by Mr. George Brown, the Parliamentary Secretary of the Ministry of Agriculture. The new course has been started by the College to help to meet the demand for specialised engineers which has arisen owing to the great increase in mechanisation in the farming industry. This course, which takes eighteen months to complete, starts with a probationary period of three months, during which a student is given aptitude tests and an introduction into the principles of internal combustion engines. During the final period of the course students will be sent to farms and establishments using and manufacturing agricultural machinery to obtain experience with equipment under actual working conditions. In the course of their training students will receive lectures and carry out practical work on the general constructional features and method of use, repair and maintenance of all kinds and makes of agricultural implements likely to be met with in a fully mechanised farm. In addition to lectures in elementary geology and soil formation, instruction will be given in crop rotation and animal husbandry. Students who complete the course satisfactorily will be given a diploma in agricultural engineering. In the course of his address when opening the College, Mr. Brown said that the new department would fill a gap in the facilities for training agricultural engineers in this country.

British Shipbuilding Research Association

THE fourth report of the British Shipbuilding Research Association covering the period from April 1, 1948, to March 31, 1950, was issued last week. In his foreword, the Chairman of the Council, Sir A. Murray Stephen, observed that the Council was satisfied with achievements and considered that, although useful results had been produced, substantial benefits would accrue to the industry. No change, states the report, is contemplated in the general policy which is to provide data, to enable ship and machinery designers to improve designs and to carry out investigations extra-murally at universities, technical colleges and the works of member firms. The ship at sea is one of the main laboratories and the co-operation of shipowners has enabled the staff of the Association to carry out many investigations afloat. A separate section of the report includes a chart of the committee system, which has functioned satisfactorily and has provided an informal meeting place for the technical staffs of member firms. By the end of the sixth year forty research reports and thirteen technical memoranda were issued, and it is expected that the flow will increase further. The intelligence section, which collects published technical information, has continued to make it available through the well-established monthly journal, which has been granted a wide circulation in this country and abroad. For the development of electronic apparatus for use on trials and apparatus for vibration work it has been decided to open a small laboratory in premises made available by William Doxford and Sons, Ltd. The widening of the distribution of the reports among the technical staffs has been considered, and, in order to strengthen the contact between the Association and member firms, it is proposed that the naval architect or the marine engineer should visit establishments to discuss the reports.

Forest Products Research

A REPORT upon the work of the Forest Products Research Laboratory, entitled "Forest Products Research, 1948," was published last week. Over fifty items of research are reported upon, and one, which has been allocated the highest priority, is the testing of timbers from overseas and especially from the Colonies. After verification of identity the timbers undergo a full range of tests and the report notes that forty-one species are either under test or awaiting test. It is hoped, as a result of the experiments, that hardwoods, hitherto unknown, may come into general industrial use and so alleviate the shortage of timber. Seasoning by orthodox and unorthodox methods has been studied, particularly with regard to radio-frequency drying, and tests have led to the conclusion that this method is only practicable and economic when applied to dimension stock of sufficient value to make speed of drying, rather than cost, the governing factor. Entomological research has formed an important part of the work and problems of insect infestation, especially pinhole borers, have been under full-scale investigation in the Gold Coast and elsewhere. Experimental spraying with DDT and Gammexane concentrations has been successful, and in this country DDT emulsions on a commercial scale have been used on timber stocks as a protection against Lyctus beetle. Tests concerned with the preservation of railway sleepers show that pressure-creosoted soft wood sleepers appear free from decay after thirteen years' service, and that incising before treatment reduces splitting. Long-term field service tests to establish the natural durability of wood have confirmed traditional information. Investigations have continued to be made in strength problems, a short series of roof tests has been made, and the suitability of pit props of home-grown hardwoods is being investigated. The survey of work on the elastic and allied properties of wood has been the subject of a separate report.

Difficulties of New Town Development Corporations

THE reports of the nine Development Corporations for the new towns, at Aycliffe, Basildon, Crawley, Harlow, Hatfield, Hemel Hempstead, Peterlee, Stevenage and Welwyn Garden City, for the year ended March 31, 1950, have just been issued in a single Government publication. The first of the Harlow Corporation's annual reports given in the publication is also the last to be made by the original body, and in its conclusions some of the difficulties under which the Corporations work are given. It is pointed out that although the Corporation is given by statute the task of building the new town, it is subject to all existing authorities which have any control over the various activities concerned with building a town. This multiplication of controls, it is pointed out, may be inevitable in present circumstances, but it creates machinery which is in some respects cumbersome almost past belief. This machinery produces in profusion officials doing one after another work that one official could well have been trusted to do himself. Development Corporations, it is considered, have too many masters. Progress of the work of the Corporation has also been unnecessarily delayed and its expenses unnecessarily swollen by prolonged scrutiny on the part of Ministry of Town and Country Planning officials of matters of detail which could have been reasonably left to the Corporation's discretion. In two particular cases, the report says, five months' scrutiny by officials ended in the acceptance of both projects subject to slight modifications which effected a reduction of some £3000 in programmes estimated to cost nearly £2,000,000. The report also draws attention to the difficulty the Harlow Development Corporation is experiencing in securing the early introduction of industry to the new town. The possibility is mentioned of there ultimately being houses in considerable numbers available without the necessary factories to provide sufficient employment for their occupants.

Naval Structural Trials

THE hull of the "Battle" class destroyer, H.M.S. "Albuera," which was declared surplus after the end of the war, has now been subjected to a series of structural tests, at the Naval Construction Research Establishment at Rosyth. The vessel was placed in dry dock, supported amidships, and loaded at the ends by means of water ballast, the amount of which was gradually increased until complete structural failure occurred. In order to give a continuous record of the stresses obtaining in various critical parts of the structure, more than 700 strain gauges were attached to the hull. From the considerable mass of data which has been collected it will be possible to make comparisons between the experimental results and the values obtained by calculation using the various strength theories. By such comparisons it is hoped that design methods may be improved so that the disposition of material in the strength girder will result in ships being of lighter construction, yet of superior strength.

The Late Mr. J. H. Johnson

MR. J. H. JOHNSON, M.I.E.E., A.Amer.I.E.E., who was a contemporary of the late Colonel R. E. B. Crompton, died at his home on December 5th. He had been with the same company since 1903, when he joined the estimating staff of Crompton and Co. (a parent firm of Crompton Parkinson, Ltd.). After serving an apprenticeship with Johnson and Phillips, Ltd., from 1894 to 1897, he studied at Finsbury Technical College and King's College. He worked for a short period as an assistant engineer with the Electric Light and Power Insurance and Maintenance Company, Ltd., and then gained further experience with A.C.E.C., of Charleroi and Kolben and Co., Ltd., Prague. In 1905, within two years of joining Crompton and Co., he became chief of the estimating department, a position which he held until just after the amalgamation with F. and A. Parkinson, Ltd., in 1927, which inaugurated the present company. He was the author of a book "Arc Lamps and Accessory Apparatus," published in 1911, and for many years he was editor of the "Electrical Engineers' Year Book." J. H. Johnson was a prominent member of the original Crompton Engineering Society and its successor, the Chelmsford Engineering Society, of which he was President in 1934–35. For the greater part of his working life he was closely associated with Colonel R. E. B. Crompton. In recent years he had been responsible for collecting a number of unique examples of Crompton's early designs and apparatus. It was mainly through Mr. Johnson's zeal that Crompton Parkinson, Ltd., was able to arrange the interesting collection of Crompton's written records, machines, instruments, arc lamps and other apparatus, which now forms a permanent commemorative exhibit at the company's Chelmsford works.

THE GENISSIAT DAM AND POWER STATION

FIG. 1—GENISSIAT DAM FROM DOWNSTREAM

FIG. 2—RESERVOIR AND RIGHT BANK SPILLWAY

FIG. 3—RIGHT BANK SPILLWAY

FIG. 4—GUIDE VANES—LEFT BANK SPILLWAY

The Development of the River Rhone

No. I

PERHAPS one of the most ambitious series of civil engineering projects which have ever been formulated in Western Europe relates to the development of the River Rhone, in French territory, for the purposes of power generation, navigation and irrigation. The well-known dam and power station of Genissiat, which was completed in 1948, forms the first of a series of hydro-electric plants, which will eventually be constructed along the course of the river, together with navigation canals. The Compagnie Nationale du Rhone, which is responsible for this work, has under construction at the present time a very large scheme on the lower Rhone at Donzere Mondragon involving a canal 28km long and a power station with a larger production of power than that at Genissiat, and a barrage and power station at Seyssel, about 12km downstream from Genissiat.

An idea of the extent of the works envisaged on the River Rhone may be obtained from Fig. 5, which shows the position and size of the proposed schemes. When these works are completed, the river will be navigable as far as the Lake of Geneva, where a port will be constructed. The power which will eventually be generated from this series of projects is expected to be about 14,000 million kWh per year (10,000 million kWh from plants downstream of Lyon) from a total of some 2500MW installed capacity. By comparison, electricity consumption in France was nearly 31,000 million kWh in 1949, of which about 11,500 million kWh was generated by hydro-electric plants.

The Rhone has the largest flow of any of the rivers in France. In its upper reaches the flow is very swift, but fairly regular owing to the natural storage provided by the glaciers and by Lake Geneva. At Genissiat, about 50km from the Swiss border, the average flow is about 400 cubic metres per second* and the slope about 3m per km; between Genissiat and Jonage-Cusset the slope is about 57cm per km for 140km. On the lower Rhone, at Donzere, between the Isere and the Ardeche the flow is about 1600 cubic metres per second and the slope 75cm per km, although for the 100km between Lyon and Valance the slope is about 50cm per km (compared with the slope of 8cm or 9cm per km of the River Seine between Paris and the sea). The river maintains its torrential character until it reaches the plains of Provence.

Following the river downstream from Geneva, the first two plants, shown in Fig. 5, at Verbois and Chancy-Pougny are Swiss, although Chancy-Pougny is controlled by both Swiss and French interests. Verbois was constructed just after the war and Chancy-Pougny in the middle years of the nineteen-twenties. Genissiat, which is situated at the downstream end of the gorges of the high Rhone, has by far the highest head (between 65·2m and 70·2m) of any of the proposed schemes and is far larger than any other plant upstream of Lyon.

Downstream from Genissiat, there will be several compensation plants, to even out the flow caused by the operation of that station. The first of these plants, at Seyssel, should be in service next year. This compensation of the river flow will be completed by the barrage and power station of Sault-Brenaz, which is the next scheme to be constructed. Work on this project is due to start next year. A head of 9·3m will be utilised and when the plant is in operation it will be possible to generate an additional 17 million kWh from Seyssel, as well as the output of Sault-Brenaz itself (260 million kWh), owing to the greater facility in compensating the uneven discharges from Genissiat. The storage provided by this scheme

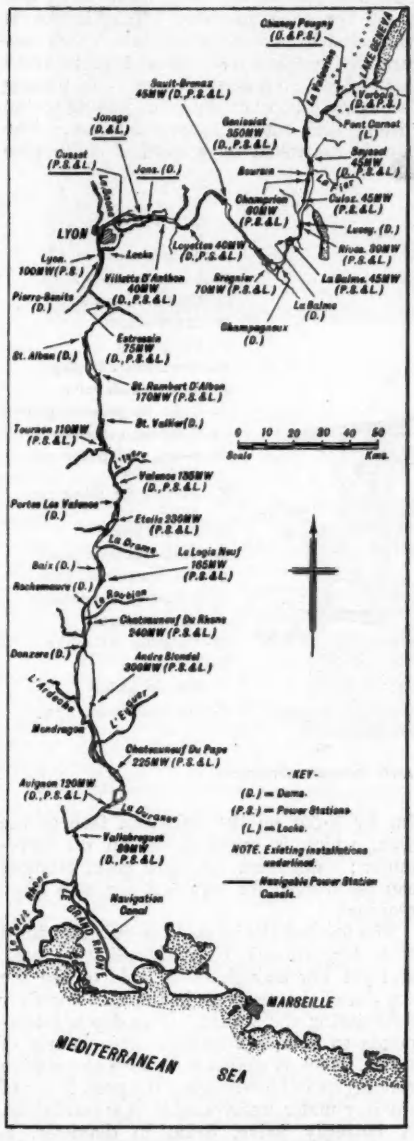


FIG. 5—PROPOSED POWER AND NAVIGATION WORKS ON THE RIVER RHONE

will be comparatively large, the reservoir extending upstream for 30km. A lowering of level of the reservoir at Sault-Brenaz by 1m would release about 11 million cubic metres of water, as compared with the 6 million cubic metre total capacity of the reservoir at Seyssel, and 12 million cubic metre useful capacity, over a range of levels of 5m at Genissiat. Altogether there will be nine power stations between Genissiat and Lyon, each equipped for a flow of 600 cubic metres per second (flow of five groups at Genissiat) and with installed capacities between 30MW and 70MW (total 435MW), according to their heads.

Just upstream of the city of Lyon are the barrages of Jons and Jonage and the power station of Cusset. These works were constructed towards the end of the last century. At Lyon itself the Compagnie Nationale du Rhone has built a port (port Edouard Herriot), which has been in operation since before the war.

Downstream from Lyon, the first of the major works projected on the Lower Rhone, consisting of the canal from Donzere to Mondragon and the Andre Blondel power station is at present under construction. In 1952, when this project is completed, work will be started near Montelimar, on the barrage of Rochemaure, the power station of Chateauneuf du Rhone and about 12km of canal. The design work on this project is now well advanced. The mean head of the power station will be 18m (13m head on the barrage) and the power production about 1500 million kWh per year. Owing to favourable site conditions it is expected that excavation will be kept to a minimum, totalling about 20 million cubic metres.

The many other projects shown on the diagram have been designed in varying degrees of completeness and will be commenced in later years as the opportunity occurs. It is evident that the entire series of projects will take many years to build.

The Compagnie Nationale du Rhone

The idea of an integral development of the River Rhone was first formulated by a Commission, which was formed in 1901. In May, 1921, a law was passed which sanctioned the development of the river for the three purposes of power development, improvement of navigation, and irrigation and other agricultural uses. This development was to be carried out by an autonomous organisation, the Compagnie Nationale du Rhone (C.N.R.), which was formed in 1934, from public and industrial concerns interested in the proposed works.

The C.N.R. has been compared with the Tennessee Valley Authority, but in fact its aims are more strictly limited to technical matters concerned with the river itself, and it does not exercise the power which is vested in the T.V.A. The only problems of a political nature with which the C.N.R. is confronted are those of expropriation of land required for projects. Nevertheless, in a densely populated and ancient valley such as that of the Rhone these problems are sometimes difficult.

Apart from the works described above, the C.N.R. has constructed several pumping stations and ancillary works in the lower reaches of the Rhone to facilitate irrigation. These works were financed mainly by the State, which took control of them in 1946.

Genissiat Dam and Power Station

The first major work of the C.N.R., the Genissiat project, has had a chequered and eventful history. The preliminary works, including the construction of cofferdams and the difficult task of diverting the river into two diversion tunnels, were carried out before the war.† During the war the site was flooded on the orders of the military authorities. Later on, during the occupation, work was resumed under great difficulties. In spite of all the obstacles, however, a large concrete plant was constructed, so that after the liberation concrete placing was able to go ahead at a rapid rate. In

* One cubic metre per second = 35·32 cusecs.

† See The Engineer December 30, 1938, page 722 and November 24, 1939, page 510.

1946, for example, nearly 300,000 cubic metres of concrete were placed.

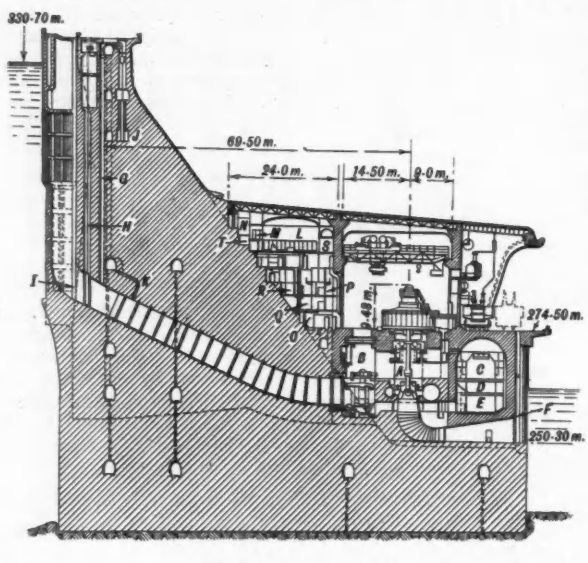
By the end of 1948 the project was completed, with four 65MW turbo-alternator sets in service, giving a power production of about 1500 million kWh per year. At the present time a fifth set is being installed, which will raise the output to about 1650 million units. Eventually a sixth set will be constructed.

Normally the sets are operated at full load during the day and almost closed during the night. This method of operation means that compensation is required lower down the river, as already mentioned in connection with Seyssel and Sault-Brenaz. For instance, during the winter the flow of the river at Genissiat is normally between 180 and 250 cubic metres per second, and the discharge of five groups under full load is about 600 cubic metres per second. The station will then function at approximately full load for about eight hours during the day and at a very much reduced load at night. There will be a change in these conditions, however, on completion of the Paris-Lyon electrification, for a proportion of Genissiat's power will be consumed on this line, which carries heavy traffic during some hours of the night. The first compensation reservoir, with a capacity of 6 million cubic metres, will be provided at Seyssel. Although the available water in the Genissiat reservoir is about twice that amount, owing to the nightly consumption of power and the natural damping effect of the river between the Seyssel and Lyon, adequate compensation will thus be obtained provisionally until the Sault-Brenaz project is constructed.

A cross section of the dam and power station at Genissiat is shown in Fig. 6, and Fig. 1 shows the dam and power station from downstream. The machines are positioned along the downstream side of the dam, which has been extended by a steel-framed roof to cover all the power station services, including the main transformers, which can also be seen in Fig. 1. It was originally intended to construct a reinforced concrete roof 3m thick over the power station, to provide protection from aerial attack, but the much lighter design in steel was substituted after the war.

The dam is a gravity structure, slightly curved in plan (500m radius) and founded on good limestone rock. It is divided by contraction joints into six principal blocks and two abutments. There is a roadway 9m wide across the top, which is at a level of 335·7NGF (NGF=Nivellation Generale Francaise), the deepest formation level being 232. Acoustic strain gauges and plumb lines have been provided in the inspection galleries, to check from time to time concrete stresses and deformations. The seepage through the dam is also measured; when first constructed the seepage was about 15 litres per second but, at the time of writing, this figure has dropped to about 2 litres per second.

The intake of water to the Francis turbines is through towers attached to the upstream face of the dam, there being one tower for each machine. This intake is connected by a vertical conduit, which was carefully designed from model tests to avoid loss of head, to a steel pressure pipe, passing through the body of the dam, leading to the turbine and thence to the tail-race. The flow is controlled by a vertical sluice gate 7m by 5·5m on the upstream face of the dam, which is operated by an oil servo-motor; upstream of this gate, stoplogs can be lowered for servicing the gate when required.



A—Turbine room
B—Butterfly valves
C—15kV switchgear
D—220kV cables
E—Pump room
F—Downstream stoplogs
G—Anti-vacuum valve
H—Guide for penstock gate
I—Upstream cofferdam
J—Servo motor for penstock gate
K—By-pass for filling penstock
L—Control room
M—Mimic diagram panel
N—Accumulator batteries
O—Auxiliary transformers
P—5kV switchgear
Q—Outgoing 5kV cables
R—L.T. cables
S—Visitors' gallery
T—Air conditioning plant

FIG. 6—GENISSIAT DAM AND POWER STATION

The level of the intake was carefully fixed to be high enough to avoid fouling by sand, and yet low enough to be able to use the top 5m of the reservoir in times of low river flow during the winter. This depth corresponds to about 12 million cubic metres of water, which is sufficient to keep the station running at full load during the peak hours of the day under unfavourable flow conditions. A butterfly valve, 5·2m in diameter, is provided at the entrance of the scroll casing of the turbine.

SPILLWAYS

Two spillways are provided, which, together, can discharge a maximum flood of 4000 cubic metres per second, which is twice as great as the largest flood known. The left bank spillway makes use of the left bank diversion tunnel and has a capacity of about 1300 cubic metres per second. There is an intake upstream of the dam with a sill level of 285·9m (i.e., 45m below the normal reservoir level), which consists of a tunnel of 100 square metres cross section, which follows a quarter circle in plan, to the axis of the dam, where it is controlled by three sluice gates, each 6·5m by 2·75m. Each of these sluice gates leads into one of three tunnels of elliptical section which pass into the diversion tunnel. Upstream of the gates the tunnel is normally full but below them the flow is free, the elliptical tunnels being in connection with the atmosphere. The guide vanes provided at the junction of these elliptical tunnels and the diversion tunnel are shown in Fig. 4. At the outlet of the diversion tunnel there is a deflector, which causes the spillway discharge to form a jet and a second deflector directs the flow away from the left bank cliff towards the centre of the stream. This type of spillway was chosen because of the necessity of periodically scouring sand from the reservoir and, owing to the extensive model tests carried out, it has not shown any undesirable hydraulic characteristics during its operation.

The right bank spillway is an open channel, controlled by three pairs of sluice gates at the upstream end. One gate of each pair controls an opening at the surface, and the second gate controls an opening at a lower level. These gates can be seen on the left of Fig. 2. The capacity of this spillway is 1700 cubic metres per second, with a normal reservoir load of 330·7, and 2700 cubic metres per second with a reservoir load of 335·7, which corresponds to the top of the dam.

The spillway flow between these two levels is intended to even out the peaks of floods and thus to facilitate the control of large floods further downstream. The spillway channel is 500m long and 18m wide, and the flow in it can reach a speed of 15 metres per second. The flow from this spillway rejoins the River Rhone 400m downstream of the dam, passing down a steep slope (see Fig. 3) and forming an impressive parabolic jet, the spray from which falls on a mattress of water and alluvium 35m thick in the bed of the river. There is also a scour pipe on the right bank, which utilises the right bank diversion tunnel and can discharge a maximum volume of 500 cubic metres per second. The structure for its control can be seen upstream of the spillway intake in Fig. 2.

ARCHITECTURE

In the architectural treatment of Genissiat full advantage has been taken of the opportunity of artistically blending the great size of the dam with the rugged appearance of the gorge. The accompanying illustrations, Figs. 1 and 2, reproduce to some extent the pleasing appearance of the completed structures. The interior of the power station, named Leon Perrier, is no less impressive, as can be seen from Fig. 7. Lighting is provided by flourescent tubes disposed vertically along the walls, and by lights rebated into the ceiling. The walls and ceiling are white and cream, and the floor is a mosaic of dark stones and the alternators are red. The visitors' gallery and the control room overlook the alternator room from the upstream side.

The high tension cables from the 15/220kV transformers, which are situated on the downstream side of the alternator room, have been led to a reinforced concrete cantilever projecting from the rock on the right bank and thence to pylons at the top of the cliff, as shown in Fig. 1: from there they pass to a switching station about 500m away. There is an administrative building on the right bank at the high level, which is connected to the power station by a lift-shaft. A navigation canal will eventually

be excavated through the plateau on the right bank.

Machine Rooms

The positioning of the power station and its foundations necessitated an arrangement of the principal machines with a large vertical distance between the turbines and the alternators. Thus, the floor of the alternator room is at a level of 274·5, and the floor of the turbine room is at 264. The weight of the alternators is carried on two lines of massive reinforced concrete arches, between which the turbine room is situated. With this arrangement it is possible to dismantle the turbine, using the four 16 tonnes cranes installed in the turbine room, without disturbing the alternators. These cranes can be electrically and mechanically coupled to lift 60 tonnes. With the four cranes together, the main shaft between a turbine and alternator can be dismantled and transported to one of the trapdoors between the groups for lifting by one of the principal cranes of the alternator room. There are two travelling cranes of 22m span, each able to lift 225 tonnes, in the alternator room. These two can also be coupled to lift 410 tonnes, the weight of a rotor. Since it was possible to erect and dismantle a turbine and alternator independently, several months were gained during the construction period.

The turbines are situated below the tail-race level, so that a relatively high speed of rotation was adopted, without fear of cavitation. There are also two auxiliary Francis turbine sets in the power station, each of 2500kW.

Table I

Turbines	Normal	Max.	Min.
Power	90,000 h.p.	100,000 h.p.	—
Head	64·5m	70m	59m
Speed	150 r.p.m.	300 r.p.m.	—
Flow	120m³/sec.	—	—
Efficiency	92 per cent	—	—

Total weight	650 tonnes
Weight of runner	35 tonnes
Diameter of runner	4 metres
Alternators	
Continuous nominal power	65,000kW
Power factor, in inductive or capacitive circuit	0·93
Nominal phase voltage	15kV
Permissible voltage variation	± 5 per cent
Frequency	50 c/s
Weight of stator	About 350 tonnes
Weight of rotor	About 400 tonnes
Transformers	
Continuous nominal power	70,000kVA
Power factor	0·93
Mean primary phase voltage (primary windings—delta connected)	15kV
No load mean secondary voltage between phases (secondary windings—star connected)	230kV

Principal Machines

The characteristics of the main Francis turbine sets of the Leon Perrier power station are given in the accompanying table, together with some figures for the transformers. Each turbine is equipped with two double-acting oil servo-motors. For maintenance, the turbine chambers can be pumped dry (there being a pump room for each draft tube) after emplacing stoplogs, shown at *F* in Fig. 6. Speed regulation is by means of oil pressure valve-relays, and an electrically controlled independent governor. The governing mechanism is installed as close as possible to the turbine on the upstream side, so that the lengths of oil pipes were kept to a minimum.

Each of the alternators has principal and pilot exciters mounted on the main shaft. Ventilation is through a closed circuit, there being two fans, one on each side of the rotor. The air is cooled by eight water coolers placed around the periphery of the machine and supplied by a pipe, which can take water from any one of the six turbine penstocks.

The stator frame is built up of welded sheet steel, and was fabricated on the site from four separate parts, to facilitate transport. Building-up of the laminations was carried out on site. The spider arms of the machine support a foot bearing, which carries the entire weight of the moving parts, the total force in the bearing being 900 tonnes. The rotor consists of a cast-steel core, keyed to the shaft, around which there is a rim consisting of a number of thin segments of sheet steel, lapped and held by numerous adjustable bolts. This rim floats off the case at speeds a little above the normal and is then guided by keys to avoid eccentricity. There is also a braking rim on the lower part of the rotor, braking being automatic or by hand.

The transformers each have a tap changer with five positions, giving voltages of ±3·25 per cent and ±6·5 per cent, with respect to the mean voltage. The neutral point of the secondary circuit is brought out and insulated for the full tension of 230kV. Cooling is carried out with radiators mounted on the transformer tank, at part loads, and with the aid of fans, at half the full load or above.

Control of the main machines is semi-automatic, the various panels in the control room consisting of "turbine" controls, for the turbines and butterfly valves and local controls; a similar panel for the "alternator" controls; control of the turbo-alternator sets, temperature recorders, tachometers, braking, &c.; control of excitation of both pilot and principal exciters, and control of servomotors, ampmeters of rotors and various relays. The various auxiliary services of the power station include CO_2 fire protection for the alternators and an air-conditioning plant for the entire building.

The following paragraph gives the firms who were responsible to the C.N.R. for the principal works at Genissiat.

Preliminary works, civil engineering: Ste des Anciennes Entreprises Leon Chagnaud et Fils. Diversion tunnel sluice gates: Etablissements Neyret-Beylier et Piccard-Pictet. Main works: a consortium of contractors, "l'Entreprise de Construction du Barrage de Genissiat," consisting of Sté des Grands Travauxde Marseille; Sté Generale d'Entreprises; Etablissements Dayde; Entreprise Desplats et Lefevre; Entreprise Fougerolle; Ste. Hersent; Regie Generale des Chemins de Fer et Travaux Publics; Schneider et Cie, and Anciennes Entreprise Leon Chagnaud et Fils. Penstocks: Bouchayer et Viallet. Principal turbo-alternators: two sets, Schneider, two sets, Alsthom. Control equipment installed by Alsthom. Principal transformers: Ste Savoisienne de Constructions Electriques. Cranes: Delattre et Frouard; Chantiers et Ateliers de Construction de Lyon. Model studies for civil works: Etablissements Neyrpic Laboratory of l'University of Lausanne and of C.N.R. Architects: MM. Laprade et Bourdeix.

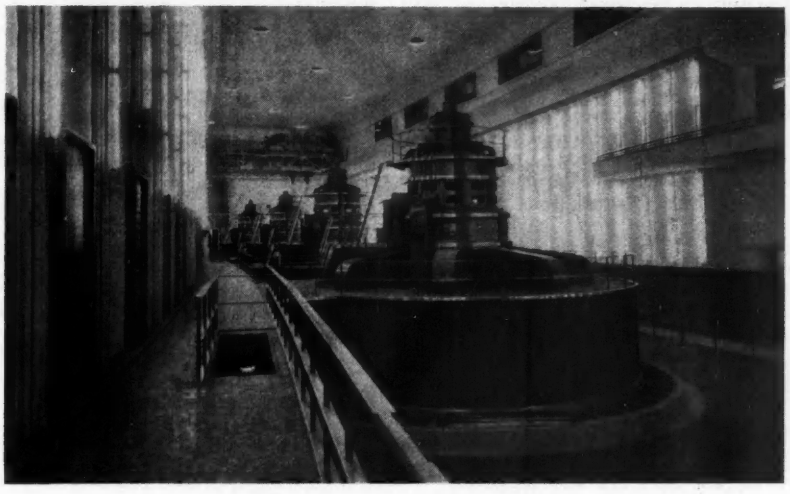


Fig. 7—Alternator Room—Genissiat

(To be continued)

A Cable Factory near Johannesburg

Quantity production of vulcanised rubber cable and cotton-covered cable will be begun soon at the Edenvale factory, 10 miles from Johannesburg, of Aycliffe Industries, Ltd., who achieved three years ago the distinction of being the first South African company to produce polyvinyl chloride insulated wire and cable. At the inception of this manufacture polyvinyl chloride was understandably regarded as an untried material in the electrical field in the Union. Reluctance to use it, however, was gradually overcome, and by degrees the P.V.C. insulated products won the acceptance of the South African industry.

Last year, Aycliffe Industries, Ltd., effected a close financial and technical agreement with Aerialite, Ltd., of England, whereby the selling organisation established by Aerialite in South Africa has been merged with that of Aycliffe Industries. Outstanding orders amounting to £25,000 for all types of plastic and rubber insulated cable have now been taken on by Aycliffe Industries. Up-to-date wire plant and cotton covering and rubber insulating plant has been imported from England and is in process of installation at the Aycliffe factory, and early production of V.I.R. and cotton-covered cable is anticipated. Technical personnel from the Aerialite factory in England have been brought out to the Union. A very considerable amount of export trade formerly handled from England will now be conducted from the South African factory, the first bay of which has been completed on a 5-acre site.

The Iron and Steel Institute

No. III—(*Continued from page 524, December 1st*)

WE continue, below, our report of the discussion on "Atlas of Isothermal Transformation Diagrams of B.S. En Steels," at the Autumn Meeting of the Iron and Steel Institute on Thursday, November 16th.

Mr. H. Allsop (Brown, Bayley's Steel Works, Ltd.) said it seemed very probable that one of the most useful practical applications of isothermal transformation data for alloy structural steels would be in connection with treatments for the controlled cooling of forgings or other products from hot working temperatures. Some form of delayed cooling was customarily applied to alloy structural steels to prevent air hardening—with its attendant risks—and also to suppress internal cracking due to other causes. In some instances, transformation in the pearlitic range might be impracticable, but in most cases a close approach to the desired effect appeared to be obtainable in a reasonable time, which might well be less than the time taken up by some of the less systematic methods at present in use and, moreover, with greater efficiency and regularity.

A few preliminary tests had been made on steels conforming to B.S. En 17 and En 56, to indicate the effect on the transformation time of varying austenitic grain size and also the refining effect of hot working on the austenitic grain size resulting from heating to a normal temperature. The steels used did not differ materially from those used for the determinations of the type diagrams in the Atlas.

The samples used were all of the same size, viz., cylinders 2in long by 1½in diameter. They were heated to the appropriate temperature, and hot worked samples were hammered on the end, the lower end being placed on a warm anvil to prevent undue chilling. The temperature during working was observed by an optical pyrometer, but it was noted in all cases that the corners, particularly at the upper end, were cooler than the body of the pieces. The unworked samples, and the hammered ones after completion of working, were quenched into a salt bath at the transformation temperature and finally water quenched. The results showed the effect of varying austenitising temperature and they also showed that the response of the materials to transformation was influenced by the temperature at which hot working was completed, that influence being due to the austenite grain size induced thereby, so that substantially the same result was obtained whether the material was austenitised at a particular temperature, or at a higher temperature, but worked down to the same lower temperature. Comparison of the results from the forged samples, notably of En 17, showed that the variation in finished forging temperature could have an appreciable effect on the resulting structure and hardness resulting from the same isothermal treatment. That observation, taken in conjunction with the points mentioned on page 14 of the report, indicated that the diagrams therein would not absolutely represent the response of hot worked steel, even in small sections, to isothermal treatment.

Mr. C. C. Hodgson (Leyland Motors, Ltd.) suggested that the sub-committee appeared to depreciate the use of its diagrams in the designing of heat-treatment schedules. Whilst the contents of the present Atlas might be of more value, to use the words of the report, "in providing a basis for appreciating the behaviour of steels when quenched in sections which do not harden completely," surely such a contingency should not now arise if the excellent advice to be found in B.S. 970 was followed. He felt, on the contrary, that isothermal diagrams could provide an excellent basis on which heat-treatment schedules could be planned, particularly the newer treatments of isothermal annealing, austempering and martempering. For such work, however, diagrams representing the extremes likely to be met in any given specification would appear to be necessary rather than one diagram based on an ideal composition. The use of isothermal annealing and martempering would probably extend in the future, particularly for case-hardening steels and case-hardened components. It was unfortunate that the Committee was not able to include case-hardening steels in their programme, and it was to be hoped that this omission would be remedied. If such work should be undertaken, particular attention should be paid to residual elements, the importance of the effect of which had been shown in some work carried out some time ago.

Mr. E. Johnson (W. Jessop and Son, Ltd.) considered that the work on which the report was based was a fine example of what could be achieved by laboratories co-operating and collaborating on a single project. Any one of the laboratories mentioned might have been able to prepare the diagrams alone, but the result would have lacked the cross checking and correlation of the work. The laboratory with which he was associated had found that the apparatus installed for the work had been of considerable value, as, indeed, had the Atlas itself. His experience was that the diagrams could be used with considerable confidence. Although some of the various types of constructional steels had not been covered, the steelmakers had now collected data on the major qualities which were not included in the Atlas. Some had obtained curves for the case and core of the carburising steels, and it would be interesting to hear whether members considered that some of these other steels should be dealt with in a second volume.

Mr. C. E. Mavrocordatos (English Steel Corporation, Ltd.) remarked that whilst it could not be said that the determination of the isothermal transformation characteristics of steels had not been of great value to the heat-treater, a great deal more work had to be done before it could be said that the full value was being derived from this field of metallurgy. On the practical side there were problems yet to be fully studied. First, there was the problem of the correlation of continuous cooling to the isothermal diagram, a subject now under consideration of which the results were eagerly awaited. Secondly, what was the effect of precipitation of primary ferrite on continuous cooling on the subsequent pearlite transformation during an isothermal treatment? That was a subject on which very little had been reported from America and nothing at all from this country.

Mr. Mavrocordatos thought that in view of the wide range of industrial steels it would be a gigantic task to publish S curves of all of them, and there seemed to be two solutions to the problem: either (*a*) to complete the work by determining the S curves of the remaining En standard steels, or (*b*) to concentrate on a few basic compositions and determine the effect of different additions. Another point on which the Atlas gave no indication whatever was the effect of the initial temperature on the transformation characteristics. There was also the difficulty of determining the S curves of fast transforming steels. From discussions with people who had used the dilatometer it seemed that it could be too sensitive with very thin wires, and microscopic work was far too tedious and laborious. X-rays did not, at the moment, seem to offer any help as they relied on air cooling rather than on quenching from the austenitising temperature to the isothermal one.

Mr. P. T. Moore (Imperial College of Science) made some observations which he said were based on experience in his own research project on transformations. Whilst he did not suggest that the different types of transformation should be indicated on the diagrams, he thought the usefulness of the curves would be considerably increased if pro-eutectoid constituents had been shown separately. This applied particularly to the ferrite, since only two hypereutectoid steels were included in the Atlas. He questioned the general use of isothermal diagrams, even indirectly, for determining the hardenability of a steel. Surely it was easier to carry out Jominy tests, thus obtaining a direct measure of hardenability rather than to determine the S curve for the steel.

Mr. A. Brown (B.I.S.R.A.) complained that the report gave no details of the experimental work and that only the results obtained were given. As regards the practical application of the S curve he said he felt that the variation of the S curve with composition within the British Standard Specification was of great importance, and that within a given specification it was possible to obtain a time factor of anything up to ten times for the start of the transformation. Such a factor was bound to be of great importance when one was developing heat-treatment schedules for particular sizes, as this factor could mean that a considerably larger section could be treated with success. Again, no details were given in the report of the effect of the previous treatment. He realised that it would be a considerable task, but it was generally agreed that the previous treatment of the materials used was of considerable importance, particularly as to mechanical working and the time and temperature of the austenitising. The practical difficulties in determining S curves for fast transforming steels were very great, as he had found when carrying out work of this nature, but information of that kind would be very interesting.

Dr. T. Ko (Birmingham University) drew attention to the effect of slow cooling on the isothermal transformation diagrams and said that the slow cooling used in the experiments was rarely encountered in practice, but the same effect might be present at a higher cooling rate in steels with a faster pearlitic transformation. Liedholm had observed that the formation of ferrite during slow cooling to isothermal transformation temperatures greatly retarded the subsequent transformation to bainite in a hypereutectoid steel. The retardation with slow cooling through the upper range was really remarkable, but little was known about it. He referred to work by S. A. Cottrell, of the Metallurgy Department at Birmingham University on the bainitic transformation of another two steels of the En 25 type and compared the results with those given in the Atlas for En 25. He said that the most recent effort at calculating hardenability from the isothermal transformation diagram,

which had the merit of simplicity, came from Jones and Pumphrey, who assumed that during continuous cooling the fractional nucleation times, i.e., the time spent in one temperature divided by the induction period at that temperature, were additive in one transformation range and that transformation would begin when the sum of such fractional nucleation times was equal to one. Finally, he said that although the austenitising conditions used in determining the diagrams given in the Atlas were adjusted to meet practical requirements, the conditions for some of the steels, such as En 18, 21, 28, 40 and 56 had probably produced a reasonably homogeneous austenite, and it would be very useful to those who were interested in the kinetics of austenite transformation if details of the transformation, such as the nature of the propearlitic transformation products, the end of such transformations, &c., if available, could be given in a supplement to the report.

Mr. F. D. Waterfall (I.C.I.) said he approached this discussion from the practical angle of the user. Practical people now had something to go on, and perhaps more than the authors of the report had been inclined to claim. A list was given in the Atlas of steels "which might be suitable for martempering in appropriate sections." Presumably many of the steels in the Atlas had been considered unsatisfactory for martempering because partial transformation during holding above the M_s point took place. But it did not follow from this fact that parts in the hardened condition, which consisted of some isothermal transformation product and the remainder martensite, were unsatisfactory. They might frequently have the required minimum hardness after hardening, or satisfactory physical properties after hardening (martempering) and tempering. The usefulness of these diagrams to the metallurgist engaged in heat-treatment, whether by oil quenching or martempering, would be considerably increased by superimposing on them continuous cooling curves showing varying speeds of cooling. Coupled with these would be the need for a knowledge of rates of cooling during quenching of varying sections of steel—preferably both surface and centre cooling rates for the section in question. This rate would presumably not vary appreciably for the different steels in the Atlas.

The diagrams in the Atlas, Mr. Waterfall continued, were all isothermal, and the question arose whether it was justifiable to apply the isothermal diagrams to quenching (continuous cooling) practice. A useful addition to the diagrams in the Atlas would be a vertical ordinate bearing the Vickers or Rockwell hardnesses to be expected on small specimens after isothermal transformation had been completed. That procedure was already being followed in the U.S.A. Izod notched bar figures, for a stated specimen size might also usefully be added, provided it was understood that the figures applied only to the specimen size given. He inquired whether any information was available on the influence of grain size on the position of the curves in the diagram and indicated a number of other steels, the determination of additional curves for which would be of particular interest. There were so many variations in proprietary brands of tool steel that to prepare transformation diagrams for all would be, for one body, a tremendous task, but curves for the more general steels might well be done. It was to be hoped that steel suppliers would in future be prepared to furnish transformation diagrams for each of the proprietary brands of tool steel they marketed. Finally, he said there were many transformation diagrams available in literature published in the U.S.A. which, if collected and examined, might well prove to be reasonably applicable to numerous British steels, thus avoiding the need for further work on the latter.

Dr. Pfeil (chairman of the Institute's Thermal Treatment Sub-Committee) promised that all the comments made would be carefully considered by the Sub-Committee.

The following paper was then presented :—"The Transformation from Alpha-to-Gamma and Gamma-to-Alpha in Iron-Rich Binary Iron-Nickel Alloys," by N. P. Allen and C. C. Early. It described work carried out to determine the effect of nickel on the rate and mode of the transformation in iron-nickel alloys.

The final papers presented at the meeting were "The Acceleration of the Rate of Isothermal Transformation of Austenite" and "The Breakdown of Austenite Below the M_s Temperature," both by F. C. Thompson and M. D. Jepson.

THE ACCELERATION OF THE RATE OF ISOTHERMAL TRANSFORMATION OF AUSTENITE

By M. D. Jepson, M.Sc., and F. C. Thompson, D.Met., M.Sc., F.I.M.

Synopsis

Part I describes the effect of a fluctuating temperature of the transformation bath, a marked decrease in the transformation time being observed in the martensite range. Most of the transformation occurs during the cooling part of the temperature cycle. Part II deals with the effect of stress on the rate of isothermal transformation which has been examined over a range of temperatures, both tensile and compressive stresses being investigated. Tensile stresses of the order of 10 tons per square inch are found to accelerate markedly the decomposition of austenite at constant temperature. Compressive stresses of a higher order seem to be required to produce a comparable effect. Below a certain minimum stress, little or no acceleration occurs, and the increase in the rate of transformation becomes greater as the stress is increased. Stresses of a fairly high order are shown to have an effect on the distribution of low-temperature bainite. A simple, rapid and sufficiently accurate method of following the course of the transformation, by measuring the load required to break notched test pieces, is described.

THE BREAKDOWN OF AUSTENITE BELOW THE M_s TEMPERATURE

By F. C. Thompson, D.Met., and M. D. Jepson, M.Sc., Ph.D.

Synopsis

After demonstrating that there is no reason to doubt that austenite in a plain carbon eutectoid steel can decompose isothermally below the M_s temperature, it is suggested that the decomposition during the actual quenching operation and that due to the isothermal transformation should be considered quite independently, and so shown in the isothermal transformation diagram. The results of dilatometric investigations show that, so far as the second factor is concerned, decomposition becomes progressively slower as the temperature is lowered, and that there is no sign of a knee in the curve. The nature of the transformation product in this range of temperature is considered, the conclusion reached being that it is martensite in the first instance, which tempers progressively as the time is increased. This leads to an acicular, bainitic product, which is of secondary origin.

Determinations of the maximum rate of breakdown, R_{max}, suggest that this is related to the temperature by an equation of the type $R_{max}=Ke^{k\theta}$. There appears to be a distinct break in the curve of temperature against this maximum rate at the M_s temperature. The characteristic $\alpha\beta$ inversion of the martensite can be observed dilatometrically immediately after quenching, but it disappears as the isothermal treatment is prolonged and the martensite transforms. The mechanism of the austenite-martensite transformation during isothermal treatment is discussed, and no reason is found to believe that it is not due to mechanical stress, just like that resulting from the quenching itself. Finally, suggestions are made as to the origin of this stress, and magnetic results are recorded which reveal changes in the austenite during the induction period.

Discussion

Dr. L. B. Pfeil (Mond Nickel Company, Ltd.) said that during the progress of the work described in the papers he had had the opportunity of discussing with the authors the interpretation of the results. Studies of small specimens were not necessarily applicable to large masses, and if the influence of stress had the importance which the authors indicated then present methods of applying laboratory test data would surely require revision. He hoped that this matter would be ventilated in the discussion in association with the question whether there was an important effect which made it additionally difficult to apply conclusions on the transformation of small specimens to large specimens. It was by no means clear that alloy steels exhibited a higher elastic limit than carbon steels, as suggested in the first paper. With regard to the second paper, he said the authors had clearly established that there was a breakdown, but the point was the interpretation of their results. The evidence was not, in his view, very convincing. The hindrance to the acceptance of the authors' views was the quenching temperature at which martensite was formed. He found it easier to think in terms of the temperature of martensite reducing internal stresses rather than increasing them in the original austenite.

Mr. C. E. Mavrocordatos (English Steel Corporation, Ltd.), discussing the second paper, said the authors endeavoured to prove that the product, which formed isothermally after a certain amount of martensite had been formed during quenching at temperatures below the M_s point, was martensite and not bainite as had been assumed hitherto. But a few points needed further elucidation before the authors' theories could be accepted. It was stated that the product of isothermal transformation was due only to shear which had been initiated by stress. If that were so, the stress must be greater immediately after the formation of the anisothermal martensite, i.e., before the second period of inactivity, a period which could be taken as having two effects on the mass, viz., stress releasing, and tempering of the fresh martensite. In either case, as time went on the system must be under a diminishing stress, in which case it was difficult to account for the sudden reappearance of a transformation proceeding at a faste rate. The very interesting magnetic test described in the paper was unfortunately stopped before the onset of fast isothermal transformation. It would be interesting to see what happened when that period of fast transformation took place. The test, as far as it went, only showed the sudden increase of the magnetic properties on the formation of the anisothermal martensite and the gradual increase during the tempering time.

Mr. E. H. Bucknall (Mond Nickel Company, Ltd.) said the authors had tackled a difficult task in trying to establish whether in plain carbon steels the product of isothermal transformation below M_s was identical with martensite, at the moment of its formation if not later. There would be varied opinions as to the extent of their success, but they were to be congratulated on their courage and on certain of their results, especially the microscopical evidence and the results in the first paper concerned with the effects of stress. They had clearly shown that both tensile and compressive stresses accelerated isothermal transformation, though doing little to alter the period of induction. In this connection it would be interesting to have definite figures for the M_s temperatures of steels A and B, particularly in view of MacReynold's evidence that stress could alter M_s, raising it by up to 70 deg. Cent. in iron-nickel alloys. The second paper gave the impression that steel A had M_s at 200 deg. Cent., and that steel B would probably have a lower M_s. It was therefore doubtful whether the authors were on completely safe ground in arguing, as they did in the first paper, that temperature oscillation mainly affected transformations below the M_s. Information on composition and M_s temperature of the second steel in the second paper would also be appreciated. All

that was said was that the steel was of eutectoid composition. As such, austenitising at 800 deg. Cent. might give an M_s anywhere in the range 350 deg. to 150 deg. Cent., and the reader was in some difficulty to understand the import of the results given. These results did not appear to be at all definite in indicating that the isothermal product tempered like martensite. The main difference between this isothermal product and martensite formed on cooling was probably in the detailed mechanism of formation, the isothermal process being a normal nucleation and growth phenomenon—with growth occurring relatively slowly—while the martensite reaction on cooling presumably had an almost infinite growth rate and nucleation factors might completely control the progress of transformation.

Mr. D. R. Thorneycroft (Mond Nickel Company, Ltd.) said the authors had confined their attention to a group of plain carbon steels for which the S curves swept to the right as the temperature fell towards M_s. The Institute's Atlas of isothermal transformation diagrams showed that for several alloy steels the S curves were upright or ran back to the left in the neighbourhood of the M_s temperature. The last-named type of diagram applied to an En 40 B, 3 per cent chromium-molybdenum steel which he had recently investigated. In this steel, of which the M_s was at 344 deg. Cent., isothermal exposure at 320 deg. Cent. produced results which he regarded as exactly concordant with those above the M_s temperature in the intermediate range of transformation. The similarity of tempered martensite structures and isothermal products formed in the neighbourhood of M_s had been strikingly demonstrated by the series of electron micrographs published by the A.S.T.M. this year for a plain carbon steel of almost identical analysis with that of the authors' steel A. Those micrographs merited close study by the authors and should be compared with the structures of tempered martensite and isothermal transformation product shown by the light microscope.

A vote of thanks to the authors for their papers concluded the proceedings of the meeting.

The Esquimalt and Nanaimo Railway

By EDWARD H. LIVESAY

No. V—(*Continued from page 519, December 1st*)

IT will be proper for me to begin this article with a quotation from an account of a trip taken in the cab of a 4000 h.p. diesel-electric locomotive, hauling the "400" between Chicago and Milwaukee, published in THE ENGINEER, September 27, 1940. "Comparisons are odious, perhaps, but inevitable when one makes one's first run on a diesel after thousands of miles on steam must be the writing on the wall—the long day of the steam locomotive of basic design seems drawing to a close.'" Ten years later I have to report that, at any rate, on the E. and N.R. the concluding words of the above quotation have been literally fulfilled—the day of the steam locomotive on that line is definitely over. In 1948 a 0–4+4–0 Baldwin diesel-electric locomotives. I thought of the latter, hammering and pounding along the rails, even when in the best of condition; often nosing and lurching around curves, hitting them with a blow and a wrench that spell wear and tear in both engine and permanent way—and then of the "400," spinning smoothly along, snaking round curves with easy flexibility, silent, sinuous, smokeless. The tardy, grudging acceleration of the steam train—the quick, responsive surge forward of the diesel. The grinding brakes of the former, often ending in a shuddering, jerky stop—the silky, determined grip of the latter's electro-pneumatic equipment. Impossible to avoid thinking: 'Surely this

FIG. 23—DIESEL-ELECTRIC LOCOMOTIVE NO. 8012—C.P.R.

tive underwent trials on this railway, with the result that during the following year all the "steam locomotives of basic design"—4–6–0, 2–8–0 and 0–6–0—were progressively withdrawn as diesels became available until all have now gone, and thirteen of the latter now reign in their stead. The mellow note of the steam-whistle no longer echoes among the crags and defiles of Malahat and Arrowsmith, nor floats across the placid waters of Saanich Inlet; instead, there sounds the throaty hoot of an air-horn. Never again will the writer "work his passage" over the Malahat incline on the "breastbeam" of a clanking 4–6–0, feeding oil into the cylinder-lubricators at intervals when the engineer momentarily shut the throttle to enable this to be done. Diesels do not call for this personal attention; their lubrication is automatic, as are many other things that on a steam locomotive demand constant vigilance. But sentimental regrets will not bring back steam to the E. and N.R.; time has marched on; it is claimed that the work will be more efficiently done by diesel power and that economies will ultimately result, particularly as regards track maintenance—that I am willing to concede at once even without definite figures to go on. This change-over from steam to diesel power on the E. and N.R. only parallels what is going on elsewhere all over the North American continent. Very few steam locomotives are now being built there; they are far outnumbered by the rival motive-power; I believe the great works of the American Locomotive Company at Schenectady are now entirely given over to diesel construction—a sign of the times indeed. In Canada the same trend is evident; the C.P.R.—of which the E. and N.R. forms a part—has built its last steam locomotive, "No. 5935," 2–10–4, of the "5920" class, working between Calgary and Revelstoke, through the Rockies and Selkirks, where it, too, will carry out its duties. As far as Canada is concerned this complete switch-over is both logical and justified, bearing in mind the many drawbacks of the use of coal and the fact that the tremendous oil-drilling campaign that has been going on for years in so many parts of the prairie and N.W. territories has indicated the existence of extensive fields of oil-bearing strata. Under enormous areas of the country anywhere between Winnipeg and Calgary, and north to the Arctic Circle, it would almost seem safe to drill with reasonable prospects of striking oil. Canada is certainly destined to become one of the world's major oil-producing countries; the diesel locomotive is assured of fuel for many a year to come. It also follows as the night the day that any Canadian youth yearning to be a coal-miner will be well-advised to give up his ambition and learn to rig an oil-derrick. In the light of the foregoing it can be claimed that preceding articles were in a measure valedictory, describing as they did the end of steam-power on the E. and N.R. For this reason I did not go very thoroughly into the engines concerned; why thresh old straw? Nevertheless, the articles will serve as some sort of record of what that steam power comprised; of the work it was called upon to do and the way it was done in 1900 and in war-time. *Vale!* We have now entered upon the diesel age and this article covers the machines that now do the entire work of the E. and N.R., the Baldwin Company having supplied me with a mass of technical information from which a selection has been made.

Neither high speed nor very heavy loads distinguish the E. and N.R. Passenger trains never exceed eight cars, say, 450 tons, and even this is exceptional, while the speed actually allowed is 35 m.p.h., only exceeded (unofficially) along stretches north of Nanaimo. Freight trains may be heavier, but are correspondingly slower and, as one type of diesel has to handle both services, a 0–4+4–0 with a maximum speed of 60 m.p.h. was chosen. Fig. 23 shows it to be a single-cab design intended for dual-directional running. The engine is of 1000 h.p. with six in-line turbo-supercharged vertical cylinders, four-cycle, 12¾in bore by 15½in stroke, developing its rated power at 625 r.p.m. It rotates counter-clockwise when looked at from the generator end.

The generator is a direct current, self-ventilated, separately excited machine fitted with interpoles and a single self-aligning roller bearing; it is used for starting the diesel engine. The armature is solidly connected to the crankshaft, and the generator and diesel engine are built on to the same bed-plate. The cylinders have cast iron liners fitted into the upper part of the crankcase; rubber rings are provided at the lower ends to seal the joint, an arrangement which permits free expansion and contraction of the liners. The cylinder heads are individual annealed iron castings attached to the barrels by alloy steel studs, each head containing two exhaust and two air intake valves and fuel injector, located in the centre of the head. The valves are rocker-operated, both inlet and exhaust valves being of alloy steel, each provided with two concentric steel springs; they are actuated by push rods, socket-mounted in cam-followers of the roller type. Valve-stems, rocker-arms and push-rods are lubricated from the engine pressure system, the rockers, springs, &c., being enclosed by detachable aluminium covers. The camshaft is driven by a roller chain located at the generator end of the engine, and is mounted in split removable bearing shells; it is made in two sections bolted together, each section being removable from the operating side of the engine. The pistons are heat-treated aluminium alloy, oil-cooled by a constant flow passing through a "cast-in" steel coil, supplied from the wrist-pin bearings and returning to the crankcase by gravity. There are four compression rings and three oil-control rings, one of the latter being above the wrist-pin and two below. The drop-forged connecting-rods are of heat-treated alloy steel, with interchangeable bearing shells, the bolts being of similar material; the wrist-pin bearing is a bronze bushing pressed into the little-end, and is lubricated through the drilled connecting-rods.

Fuel injection is by the solid-injection system, with spring-loaded multi-hole spray nozzles, a fuel pump being provided for each cylinder; a motor-driven pump transfers fuel oil from the storage tank through a cartridge-type filter, and charges a fuel line from which the fuel-injection pumps take their supply; relief valves and cut-off valves are placed in the fuel-line, the pressure being indicated by a gauge in the cab. An over-speed stop shuts the engine down if it exceeds the predetermined maximum setting; it operates by centrifugal trip, driven from the camshaft by gears. The governor is a hydraulic relay unit, gear-driven from the camshaft, and manually controlled from the cab; it maintains the proper engine speed by controlling the amount of fuel delivered to the injection pumps. The governor oil pressure actuates the load control valve in correct sequence through the exciter field of the transmission system.

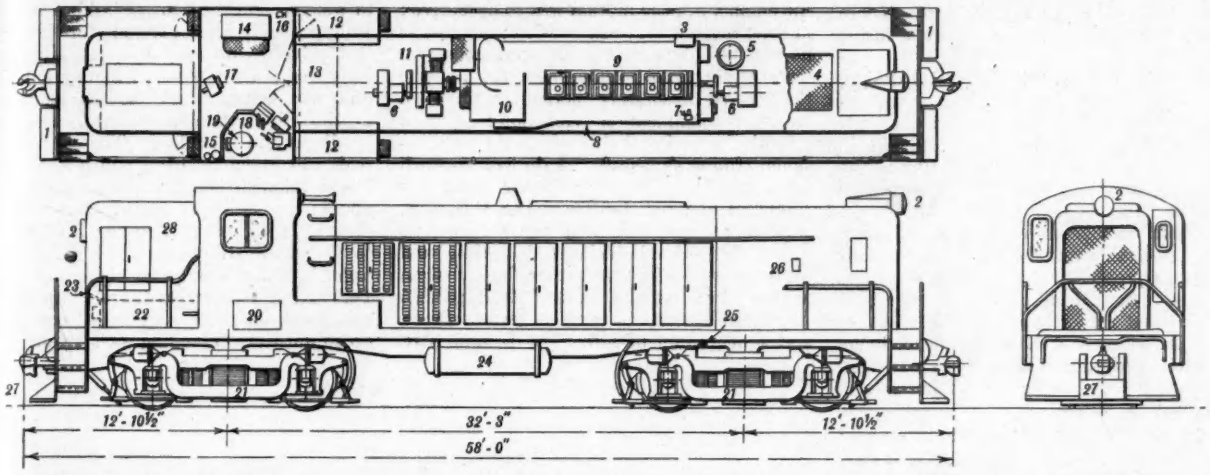
Lubrication is by a pressure system, the oil being circulated by a positive displacement gear pump, chain-driven from the crankshaft. The oil supply is contained in the engine base, whence it is drawn by the pump through a suction strainer and delivered, through a four-element filter, to a metal edge full-flow strainer and heat exchanger. From here it is delivered to the inlet header on the engine, and thence under pressure to the main bearings. From these bearings the oil passes through the hollow crankshaft to the crankpin bearings, and to the wrist-pins via a passageway in the connecting-rods. The crankshaft is a heat-treated steel forging, drilled for pressure lubrication; the crankshaft journals are 8¾in in diameter, and the crankpins 8¾in. It is supported in bearing shells fitted to the bed-plate; the bearings are removable through inspection doors without disturbing the crankshaft.

The engine is a welded steel structure forming one with the cylinder housing and the upper part of the crankcase.

Coming to the electrical equipment, the main generator has already been touched upon; the auxiliary generator and exciter unit is mounted on the main generator, and is driven by vee-belts from an extension of the main generator shaft. It provides power for charging the storage batteries—used for starting the engine—control circuits, lighting system and fuel-pump motor; a voltage regulator maintains a suitable voltage at all engine speeds. The exciter is a differential machine, providing power for the fields of the main generator, and, in conjunction with an engine-control load-regulator, it maintains full engine output over the entire operating range. The traction motors, of which there are four, one to each axle, are nose-suspended, driving through a single-reduction gear ratio of 14/68. They are series wound and force ventilated by blowers which operate through a spring-loaded air duct between the motors and air conduit. Electro-pneumatic control is provided to operate the traction motors from the generator; it is so arranged that the locomotive performance is in accordance with the tractive effort curve plotted in Fig. 25.

The unit switches and reverser in the main circuits are electro-mechanically operated; a relay operates a buzzer in the cab, warning the driver when a pair of wheels slips, at the same time automatically reducing power until the slipping stops, when power is automatically reapplied to coincide with the position of the throttle. Control cabinets are mounted adjacent to the engine; they contain control equipment for both main and auxiliary circuits, and are made easily accessible for inspection and maintenance. The storage battery provided for engine starting and standby lighting is charged from the auxiliary generator; it is controlled by a voltage-regulator and protected by a reverse current relay and charging resistor. The headlights have dimming control, and electrically-lighted number boxes are placed on each side of the engine.

Engine cooling is carried out by a chain-driven centrifugal pump and is adequate to cool both water and lubricating oil under full load conditions. Thermostatically controlled shutters, in conjunction with a propeller fan, ensure that the engine shall run at the correct temperature. Each cylinder has inde-



1, Switchmen's steps; 2, headlight; 3, heat exchanger; 4, cooling system, radiator cores, fan and drive; 5, lubricating oil filter; 6, traction motor blower; 7, lubricating oil filler; 8, engine compartment; 9, diesel engine; 10, main generator; 11, air compressor; 12, storage batteries; 13, electrical equipment cabinet; 14, helper's seat; 15, fire extinguisher; 16, hand brake; 17, cab heater; 18, operator's controls; 19, operator's seat; 20, air brake equipment; 21, motor truck; 22, fuel oil tank; 23, fuel oil tank filler; 24, air reservoir; 25, water filler, diesel engine; 26, sand box filler; 27, pilot; 28, rear compartment.

FIG. 24—GENERAL ARRANGEMENT OF DIESEL-ELECTRIC LOCOMOTIVE

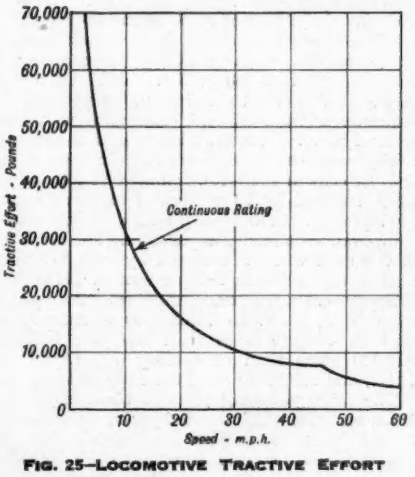


FIG. 25—LOCOMOTIVE TRACTIVE EFFORT

pendent piping and there is an expansion tank and pipe connection for filling, draining and steam connection.

Automatic straight air-brakes are fitted, with train connections at both ends of the engine; the air reservoir is conveniently placed under the frame between the trucks for inspection and testing; it is of ample capacity and fitted with a safety valve. The air compressor is compound, and is fitted with an unloading control, set to release at 140 lb per square inch. There is also a hand-brake, worked from inside the cab.

The bogies are of swivel-pedestal design, of one piece cast steel frame construction, fitted with equalisers, bolsters and suitable springs. The wheels are 3ft 6in in diameter and the wheelbase 9ft 10in; the engine wheelbase is 42ft 1in. The brakes are of the clasp type, applied to all wheels. Centre-pin bearings are employed, with high carbon steel side and bottom liners, lubricated and protected by dust-guards. The axles are of forged steel with bearings 6½in by 12in, and the wheels have heat-treated rims 5½in wide. A.A.R. automatic couplers are fitted, with uncoupling levers arranged to operate independently from either side.

The cab is constructed of metal plates and shapes, thoroughly braced and welded; the entire unit is rigidly fixed to the underframe. Both fixed and movable metal window frames are provided wherever required; the doors are of metal, and both windows and doors are glazed with shatterproof glass. The cab walls and ceiling are lined with insulating material and rain-gutters are placed over the outside doors and movable windows. Cab fixtures include cushioned seats with upholstered arm rests, pneumatic window-wipers, fire extinguisher, electric light, heater, brake gauges, wheel-slip indicator, headlight and engine compartment light controls, bell, horn, and sander. The engine compartment is built of sheet metal substantially braced, and is designed for ready access to and removal of equipment. Roof hatches give easy access to cylinder-heads and other parts; ventilation is obtained through side louvres; and fixtures for inspection lamps are provided, while the flooring is non-slip. Air-operated sanders are fitted, to operate in either direction, and the boxes are filled from outside the engine.

The approximate weight in working order, is 224,000 lb, and light 211,400 lb. The overall dimensions are: width, 9ft 11½in; height 14ft; length (inside couplers), 58ft; overhang, front and rear, 12ft 10½in. The following supplies are carried: lubricating oil, 170 gallons; fuel oil, 900 gallons; cooling water, 250 gallons; sand, 30 cubic feet; air capacity, 58,000 cubic inches. The starting tractive effort is 67,200 lb, and continuous rating 32,400 lb at a speed of 9·5 m.p.h.; the maximum safe speed 60 m.p.h. Multiple unit control is available if necessary—this is unlikely on the E. and N.R. The minimum curve radius that can be safely negotiated with a train is 191ft, or 30 degrees.

Fig. 25 shows the tractive effort at varying speed; it is self-explanatory. It is evident that the engine is far more powerful than the steam locomotives it replaces, the starting t.e. being approximately double. The diesel, too, is likely to be far easier on the track, inasmuch as though the total weight of the two types is much the same, 100 tons for the diesel and 91½ tons for the 4–6–0, and the weight on individual driving axles also closely corresponds, 25·0 and 23·5, respectively; the absence of hammer-blow and the far greater flexibility of the diesel are bound to have considerable effect. At the moment of writing I have not yet ridden the diesel and though I do not anticipate finding such perfection of action as I experienced on the twin-unit A–1–A+A–1–A Chicago North Western machine—quoting: "Curves were taken with an easy, serpentine grace that it was a delight to feel. Switches and crossovers were imperceptible. . . . I was fascinated by the silky motion of the engine. . . . the motion was so deceptive; in fact, there wasn't any motion; there was no feeling of wheels rolling on rails—we were gliding, not rolling along. . . . the riding was absolutely perfect, without a trace of roughness or vibration; just a smooth, humming flight, with only an occasional trifling side-sway," I do look forward to something altogether better than the riding of the old 4–6–0's. The C.N.W.R. engine, though built ten years ago, was intended to haul high-speed trains, and attained velocities altogether higher than are required on the E. and N.R.; 100 m.p.h. and over was reached several times, and a maximum of 110. The E. and N.R. engines are really glorified "switchers," and their riding may be expected to be correspondingly rougher. The facts, however, will be set forth in the next article.

The table giving the loads these engines are capable of hauling under varying conditions of speed and gradient show that they are capable of far more than will ever be demanded of them on the E. and N.R., either now or in the foreseeable future. Passenger trains are not likely to increase in weight; on the contrary, more and more will probably be catered for by buses and private cars as the Island Highway is improved; large sums of money have been and are being spent on its betterment, in the elimination of curves, reduction of gradients and widening. The old pack-trail over the Malahat, from which the railway has developed, has already become history, and in a very short period there will be a fine, wide highway extending from Victoria to Campbell River—and the accident rate upon it will probably be higher than ever! Personally, I prefer to travel "up Island" on the E. and N.R., and shall continue to do so until my travelling days are over.

(To be continued)

The British Electricity Authority's Annual Report

THE second annual report of the British Electricity Authority and the corresponding reports of the fourteen Area Electricity Boards for the year ended March 31, 1950, were published on Tuesday, December 5th.

Production and trading figures given in the reports show that over 49,000 million units of electricity were generated at power stations owned by the Authority. This output was 6·3 per cent above that of 1948–49 and double that of 1938–39. A corresponding increase was shown by the sales of electricity to consumers which totalled 41,500 million units. Of these sales, half were to industry, one-third to domestic consumers, and one-eighth to commercial users. Industrial consumption of electricity increased by 8 per cent (compared with 9·5 per cent in 1948–49), commercial consumption increased by 10 per cent (compared with 20·1 per cent in 1948–49), and domestic consumption, which was comparatively low because of the mild winter, increased by only 1·9 per cent (compared with 7·3 per cent in 1948–49).

At the end of the period under review supplies were being given to 12,634,000 consumers—that is, 452,000 more than the year before, 918,000 more than at vesting day (April 1, 1948), and 2,500,000 more than before the war.

The average selling price of electricity was 1·2d. per unit, which was 2·2 per cent above the 1948–49 average, 5·9 per cent above that of 1947–48, and 14·3 per cent above the average price in 1938–39. The increase compared with 1948–49 reflected the full effects of the consumer tariff adjustments made in that year. No general changes in consumer tariff were made during 1949–50. Commenting on the price, the report points out that the increase of one-seventh in the average price per unit, compared with the pre-war figure, was much less than the increase in the prices of coal and most other commodities, or the increases in wage rates and in the general cost of living; indeed, the average price of electricity (1·515d. per unit) sold to "domestic, commercial and small power" consumers was 5·1 per cent below the pre-war average.

The combined revenues of the Authority and the Area Boards exceeded by £7,163,236 the amount of their outgoings properly chargeable to revenue account. This surplus was £2,771,552 more than that of 1948–49, and the total surplus for the two years was £11,554,920.

Generating Capacity and Programmes

At March 31, 1950, the Authority owned 293 power stations with a total installed plant capacity of 13,784,000kW and a total output capacity, with all plant in service, of 12,337,000kW. Compared with a year earlier, the net increase in installed capacity was 939,035kW, and in maximum output capacity 783,000kW (6·8 per cent). The power stations differ greatly in size, and about one-fourth of them generate nine-tenths of the total output. Because of the shortage of plant, it is necessary to retain in operation many generating sets and boilers which are old, small and expensive to operate. Over a third of the sets and of the boilers, representing in each case over 11 per cent of the total capacity, are twenty-five years old or more. More than half the sets, representing over 10 per cent of the total capacity, are rated at below 8000kW, as compared with the present standards of 30,000kW and 60,000kW. More than a third of the boilers, representing over 9 per cent of the total capacity, have evaporative capacities of under 40,000 lb per hour, as compared with the 250,000–550,000 range for most of the boilers under construction.

A million kilowatts (installed) of new generating plant, distributed among twenty-one power stations, were brought into service in 1949–50, giving an additional output capacity of 831,000kW (sent out). The stations included three large new ones—Walsall, Littlebrook B (Dartford) and Staythorpe (Newark)—which were opened during the year. Some 60,000kW of plant were closed down, the bulk of which consisted of old plant which it was necessary to remove to make room for station extensions. At the end of the year, forty-three new stations and twenty-seven extensions to existing stations were under construction or planned in the programmes up to and including 1954.

During the year the Authority prepared the programmes of plant to come into commission in 1954 and 1955, the sizes of the programmes being governed by the amount of plant which the manufacturers were likely to be able to supply. Altogether, the plant capacity programmed for 1946–55, inclusive, amounted to

10,330,000kW (sent out), of which 1,745,000kW had been brought into service by the end of 1949. Including for the earlier years some plant from earlier programmes, 307,000kW were brought into operation in 1946, 340,000kW in 1947, 566,000kW in 1948, and 703,000kW in 1949. Although the delays due to economic difficulties persisted, the rate of completion was steadily improving, and in the year ended March 31, 1950, the amount of new plant brought into service rose to 831,000kW (sent out).

Power Station Construction and Plant

The cost of construction of buildings and plant for power stations continued to rise. It was estimated that the average capital cost of providing the new stations and extensions of existing stations included in the 1950–53 programmes would exceed the figure, given in the first report, of £50 per kilowatt installed. It would be some three times as much as before the war. Power station capital contracts approved by the Authority in 1949–50, largely in respect of capacity to be brought into commission in 1952, 1953 and 1954, amounted to £68 million, as compared with £42 million in 1948–49. About a quarter of the total was in respect of civil engineering and building works, and the remainder in respect of plant.

Three-quarters of the generating capacity approved for the programme years 1953–55, inclusive, was in respect of standard 30,000kW and 60,000kW sets. The non-standard sets comprised duplicates of existing sets which were necessary to continue the development of stations begun before the evolution of the standard machines, and also a number of new designs to encourage development of plant operating at advanced steam conditions. Further study was made of design details of the unit type of installation, in which a single boiler is associated with each turbo-alternator; this type will form a major proportion of the new plant.

One of the new stations (Castle Donington) will have turbo-alternators of 100,000kW, the steam pressure at the stop valve being 1500 lb. per square inch and the temperature 1050 deg. Fah.; each will be supplied with steam from an associated boiler capable of producing steam at the rate of 830,000 lb per hour. Investigations were continued to assess the economic and technical possibilities of installing on the unit system large-capacity reheat sets and their associated reheat boilers. They would operate under advanced high-pressure and high-temperature steam conditions, the steam, after passing through the high-pressure section of the turbine being reheated to a temperature equal to or approaching the initial high temperature before being used in the low-pressure section.

Generation of Electricity

The overall thermal efficiency of generation was improved by the high efficiency of the modern plant brought into operation, by careful attention to the condition of existing plant, by improvements in the distribution of fuel supplies to the power stations, and by the optimum loading of plant. The thermal efficiency of the Authority's steam stations increased from 20·86 per cent in 1947–48 to 21·15 in 1948–49 and to 21·33 in 1949–50.

Average works costs per unit sent out from the steam stations of the Authority fell from 0·4981d. in 1948–49 to 0·4872d. in 1949–50, or by 2·2 per cent. The reduction of 2·7 per cent in fuel costs per unit, which accounted for most of the decrease, was due to the reduction in heat consumption per unit consequent upon the improved efficiency of generation, and to the drop of 1·9 per cent in the average delivered price per ton of coal and other fuels.

The Authority continued to be the largest purchaser of fuel in Great Britain, consuming in its power stations in 1949–50 some 29·24 million tons of coal, 0·84 million tons of coke, and 0·05 million tons of oil and other fuels. Total fuel consumption was 5·9 per cent more than in 1948–49, and the corresponding increase in electricity generated was 6·3 per cent. The difference between these two percentages reflects the improvement in efficiency of generation which was obtained during the year. The electricity supply industry continued to use a greater proportion of low-quality coals than any other industry, the coal supplied to the power stations during the year comprising about 9 per cent graded coals, 28 per cent cleaned smalls, and 63 per cent uncleaned smalls. About 16 per cent of the coal was opencast coal, and here, also, the Authority were the biggest users.

There was a fall during the year of 1·4 per cent in the average delivered price per ton of coal. Despite this, the price of the low-grade coal mainly used by the Authority was still so little below that of higher-grade coal, that it continued to be more economical to use such higher grades as could be obtained.

The Grid System

At March 31, 1950, the national grid comprised 5424 route-miles of main transmission lines and cables, of which 3753 operated at 132,000V and the remainder at 66,000V or lower voltages. There were 367 sub-stations, with an aggregate transformer capacity of 15,380,800kVA. During the year there was a net increase of 121 route-miles in the grid and of 865,700kVA in the total capacity of the sub-stations, and the major transmission works put in hand included provision for 292 route-miles of 132,000V lines and cables. The value of main transmission contracts approved by the Authority during the year amounted to £10·1 million, as compared with £5¾ million in 1948–49.

During the year the Authority decided that, additional to the existing grid, a 275,000V system of main transmission, capable of meeting requirements for at least the next twenty years, should be planned forthwith, and that consideration should be given to designing the towers for certain sections of this system for later operation at a still higher voltage. A detailed programme was being prepared for the construction of those stages of the system necessary to meet requirements up to 1960, and those immediate reinforcements of the existing 132,000V system which will subsequently form part of the 275,000V system, will be designed and constructed for the higher voltage. Construction was proceeding on 41 miles of 132,000V line designed for later operation at 275,000V, and experimental work with 275,000V equipment continued at British Electricity Laboratories.

Extent and Consequences of Plant Shortage

Figures relating to the present plant shortage emphasise the gravity of the situation. In the winter of 1949–50, the shortage of generating plant at the time of maximum demand, i.e. the difference between the available plant capacity and the potential demand for electricity when the latter was at its highest, was estimated at 1,518,000kW (sent out). This was equivalent to about an eighth of the output capacity of the total plant available at the time, and it was estimated that the shortage would have been 2,140,000kW if the weather had been extremely cold and there had been no load-spreading arrangements by industrial and commercial consumers. It was further estimated, in March, 1950, that in the event of extremely cold weather and without arrangements for load spreading, there would be, at the times of maximum demand in the winters of 1950–51, 1951–52 and 1952–53, plant shortages of 1,889,000kW, 1,745,000kW and 1,702,000kW (sent out), respectively. The estimates were based on an assessment of the prospective maximum demands and the availability of plant, old and new. They indicated the amount of additional plant required, over and above the new plant coming into operation in these years from the large construction programmes now in hand, to enable full supplies to be given at all times.

The shortage of plant makes the control of the grid system exceedingly difficult, and the position is aggravated by the uneven distribution of the shortage. In order to minimise load shedding, it is necessary to make heavy transfers of power between areas. There are occasions when the loading on the transmission system is critically high, and a fault on a particular line might lead to extensive failure of supplies. At times, load has to be shed in certain areas to prevent overloading of transmission lines, although there are surpluses of generating capacity elsewhere. All this pressure on the system increases the difficulty of taking lines out of service for essential maintenance and overhaul, and a delicate balance has to be struck between the risk of operating with reduced transmission capacity and the risk of transmission failure if necessary works are curtailed. In order to meet the greater winter requirements for electricity, maintenance and overhaul of both generating and transmission plant are carried out as far as possible in the period April to October inclusive, and at weekends. Hence, even in the summer months the margin of plant available to meet above-normal demands is practically non-existent.

The restrictions on the acceptance of new consumers, on the types of load which can be accepted, and on the extension of the distribution networks to secure new business, have appreciable commercial consequences. The steady reduction before the war in the price of electricity was secured by technical advances whereby the costs of production were progressively reduced (in particular by reductions in the quantity of fuel required to produce a unit of electricity), and by improvement of the load factor to secure that each pound sterling of capital and other overhead costs of supply should be spread over a larger number of units.

While recognising the onerous and difficult nature of the Government's responsibility for determining the best uses of limited resources in the national interest, the Authority have expressed the firm opinion that, apart from generation, the amounts allocated for 1950 are insufficient to meet the industry's needs and to maintain balanced development. Of the total of £102 million, some £54 million is for generation, £5 million for main transmission, £35 million for distribution, and £8 million for "maintenance and repair." The provision for main transmission, and for maintenance and repair, will not cover necessary requirements under present conditions. In the field of distribution (i.e., the capital expenditure of the Area Boards in providing supplies to consumers) the effects of restriction will be severely felt.

The Authority and the Area Boards are making every effort to secure that as soon as possible they will be in a position to meet all consumer requirements. Unless, however, the annual programmes of new generating plant can be speedily increased from the 1950 level of about 1,000,000kW (sent out) to at least 1,800,000kW (sent out), it will be many years, on present expectations of the growth in demand, before full supplies can be given at all times. Subject to the limits imposed by the amount of manufacturing and construction capacity likely to be available, annual plant programmes of increasing magnitude have been planned by the Authority, rising to 1,800,000kW (sent out) by 1956–58. These big progressive programmes have been planned after close consultation with the manufacturers of turbo-alternator and boiler plant, and their realisation will require a supreme effort on the part of all concerned; but they are physically capable of achievement, provided they are not adversely affected by other national considerations. Present-day uncertainties make it impossible to give any firm promise as to when plant capacity will be sufficient to meet all demand. If, however, the programmes are carried out and the growth in demand accords with present expectations—that is, taking the most favourable view—the shedding of load by switching-off consumers should be comparatively infrequent by the winter of 1954–55, and very exceptional in the three following winters, even if the weather is extremely cold. Reductions in frequency and voltage, at a diminishing rate, will still be necessary during these four winters.

Agricultural Machinery Exhibition at Earls Court

No. I

THIS week the Smithfield Club Show and Agricultural Machinery Exhibition is being held at Earls Court, London. The first Smithfield Show took place in 1799, and it soon became established as an annual event of considerable importance to farmers, cattle dealers and meat traders. Until 1938 the show was staged at the Royal Agricultural Hall, Islington and, as the years passed, an increasing amount of space became devoted to the display of agricultural implements and other equipment.

PICK-UP BALER—MASSEY-HARRIS

During the period of the second world war it was, of course, impossible for the "Smithfield" to be held, and ways and means of reviving it could not be found until last year. Then a joint committee, representative of the Smithfield Club, the Agricultural Engineers' Association and the Society of Motor Manufacturers and Traders, Ltd., became responsible for the organisation. Its efforts resulted in an exhibition, which retained the tradition associated with the pre-war cattle show, but which also gave the necessary emphasis to the big part which engineers play in the practice of present-day agriculture. For that reason, Earls Court was selected as the most suitable place for the exhibition, and in view of the extent of the machinery section, no more suitable location could have been chosen.

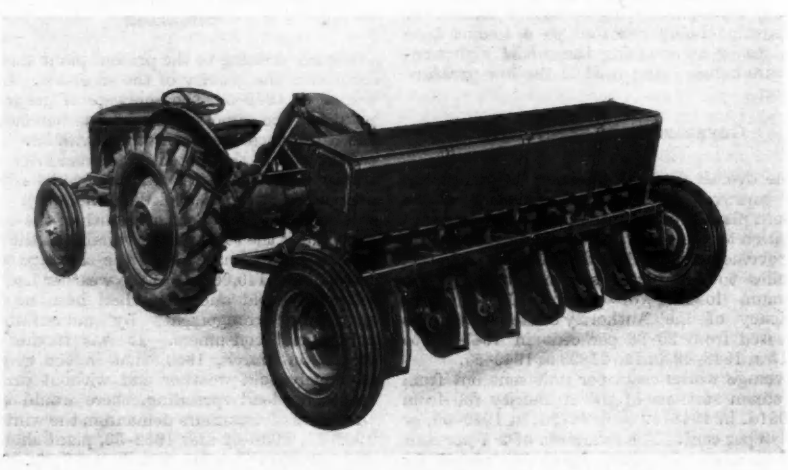
This year's exhibition, which opened on Monday last, December 4th, and closes this Friday evening, is even more extensive. There has been an increase in the livestock entries, bringing them near to the 1938 total, and there is also an increase in the number of stands occupied by the agricultural machinery and allied trades. Those stands, conveniently arranged on the lines followed by the Society of Motor Manufacturers and Traders for the other exhibitions which it organises, provide an effective and instructive display of the numerous implements and other items of equipment which engineers are producing to assist the business of modern farming. As Captain E. N. Griffith, President of the Agricultural Engineers' Association, pointed out last week, Great Britain now ranks second only to the U.S.A. in the manufacture of farm equipment and to-day there are more tractors on United Kingdom farms than in the whole of Canada.

The second in the new series of Smithfield shows certainly demonstrates how agricultural engineering is adapting its varied products to the needs of British agriculture and how it also continues to make a valuable contribution to this country's export trade. The many visitors to this week's exhibition have included farmers and engineers from different parts of this country and from several overseas countries, which are anxious to study British farming methods and equipment. It has been suggested recently, however, that stability in the design of agricultural machinery is now being reached. That impression tends to be in a large measure confirmed by a general study of the exhibition at Earls Court, although there is plenty of evidence that improvements to existing designs are continually being made.

It has become customary for agricultural machinery makers to introduce their newly designed products each year at the Royal Show. Thus, the majority of the tractors and implements displayed at Earls Court have already been seen in another part of the country, though it is the first occasion on which they have been shown in London. Many of them, of course, have already been described and illustrated in these pages.

Throughout this year engineers have concentrated a great deal of attention upon forage harvesting machinery. A competition for British made machines of this nature was organised by the Royal Agricultural Society and included a series of field trials—under particularly difficult conditions—of machines already in production and also of prototypes. Some of the machines for dealing with green crops and hay and straw, which were entered for that competition, are to be seen at Earls Court, and there are one or two others which have since been introduced. Among the latter is a one-man pick-up baler, produced by Massey-Harris, Ltd., Barton Dock Road, Stretford, Manchester. This baler, which is illustrated in an accompanying engraving, is a machine of all-steel construction, with an overall length of 22ft 6in and weighing approximately 1½ tons. By means of a three-bar type spring tine pick-up and elevator carrier chains, the material is fed into an auger and thence delivered to a feeding head to be dealt with by the knotting mechanism. A powerful fan is fitted to keep the knotter clear of trash. As the baler is powered by a four-cylinder air-cooled engine, its operation is independent of the tractor, which tows it. The same firm is showing a new rubber-tyred hay rake, which can be speedily hitched by an adjustable draw-bar to any make of tractor. By means of trip ropes, the tractor driver is able to maintain complete control of the rake, the outer tines of which can be folded inwards to enable passage through gateways or narrow lanes. A screw depth adjustment is provided for altering the position of the tines. With its forty-eight tines, the rake has a working width of 14ft 2in and a transport width of 8ft 4in.

The range of mounted and attached implements built by the various manufacturers of British tractors continues to expand. One recent example is the universal seed drill, shown on the stand of Harry Ferguson, Ltd., Coventry, a photograph of which is reproduced on this page. The drill is of all-steel construction, with an overall width of 8ft 11in, and it has been specially designed for attachment to the Ferguson hydraulic lift linkage. It is equipped with a force-feed fluted roller-type seeding mechanism and the implement can be employed for sowing a variety of seeds from beans and large maize to turnip, lucerne and other small seeds. The hopper of the drill is only 41in above ground level and can therefore be filled with ease, and the specially rust-proofed feed tubes are very flexible when the implement is in operation. The drill can deal with thirteen rows at a time at a maximum row width of 7in, but by means of stop plates inside the hopper drilling can be at any desired width up to a maximum of four rows 28in apart. Coulters, which are easily detachable, cover the seed, and drilling depth can be adjusted by a control handle and a rack on the tractor top link. When the coulters are raised out of work, the feed is automatically cut off and is automatically restarted as soon as the coulters are lowered



GRAIN DRILL—FERGUSON

again into work. The single-speed drive from the ground wheel is transmitted by roller chain and machine-cut gears. The rubber-tyred ground wheels are positioned to give the best load distribution calculated to ensure maximum traction on the tractor wheels.

Another new tractor-drawn implement on show for the first time at Earls Court this week is the single-furrow deep-digger plough, which is being produced jointly by Ford Motor Company, Ltd., Dagenham, Essex, and Ransomes, Sims and Jefferies, Ltd., Ipswich, Suffolk. It is arranged for attachment to the three-point linkage of the Fordson Major tractor and has been designed to stand up to the most varied and arduous operating conditions. There are many farmers who insist on deep ploughing for root crops and many others who are now engaged on land reclamation schemes, and the makers claim that both categories have been kept in mind throughout the design and development of this plough, which is illustrated by one of our engravings. The superstructure of the new plough is made from 3in by 1in and 3in by ¾in high carbon steel and is semi-pin jointed. Each of the plough bodies is fitted with a tailpiece as standard equipment, though provision is made for a choice of integral wing and point shares on bar points. The single-sided disc coulter has a cast coulter arm carrying an 18in diameter disc, but, if preferred, knife coulters can be fitted. The skim coulter is mounted direct from the plough beam and may be adjusted for depth and width and also fore and aft along the beam. There is an under-beam clearance of 28in and the plough has a variable width of cut from 16in to 18in, controlled by a screw lever. The implement will plough to a depth of 14in and, even at the maximum depth, the makers claim that there is effortless and precise control. This control is effected by means of a screw-type lever operating on a single piece axle and cross-shaft, which varies the height of the disc-type depth wheel. The pressed steel disc-type depth wheel, it may be added, is fitted with an adjustable scraper. Front furrow width control is by means of a screw lever operating on a standard cranked cross-shaft, and the pitch of the implement can be varied by adjusting the top link of the tractor's three-point linkage.

In passing, it may be mentioned that the Ford Motor Company's exhibits also include a full crawler version of the Fordson Major tractor, fitted with a 45 B.H.P. Perkins P.6 diesel engine. The tracks, which have been designed to resist wear, are built up on a three-point mounting. The machine is steered by hand-operated clutches, assisted by foot-operated independent brakes.

In recent years, farmers have shown a good deal of interest in the principle of "rotavation," or rotary cultivation. Rotary Hoes, Ltd., East Horndon, Essex, is exhibiting a selection of the Rotavator attachments, which are now being built to work with most of the standard makes of tractor. The example which we illustrate, is the latest addition, having been adapted specially for use with the David Brown "Cropmaster" tractor. The makers emphasise that the Rotavator is not operated by towing. It is integrally attached to the tractor by means of four linkage points secured by pins, the rotor being driven from the power take-off through a Hardy Spicer coupling. The rotating action of the blades, which revolve in the same direction as the land wheels, creates a forward thrust, thereby assisting the forward movement of the whole unit. Thus, it is suggested, less power is absorbed than is required for converting the rotary motion of the tractor engine into horizontal draw-bar pull necessary for towing "dead" implements. Each of the Rotavator blades is a true hoe blade, so shaped as to have a positive cutting and dividing effect on the soil, and is held by two substantial bolts. The working width of this attachment is 4ft 2in, and it is possible to adjust the depth for all general tillage operations between 0in and 10in. The lever engaging the rotor drive is placed conveniently to the tractor driver's seat, and there is an automatic safety clutch in the drive to enable stumpy or stony ground to be worked without damage to the machine from hidden obstacles.

There are also some smaller editions of the Rotavator, which have been designed for market and private garden use. In each the same principle of rotary cultivation has been followed. One of these machines, the "Bantam," is powered by a 2 h.p. Villiers two-stroke engine, with a gearbox providing for two speeds. In addition, two further speeds can be effected by moving the driving belt to the alternate engine pulley provided. This machine is controlled by handlebars, which are adjustable both laterally and for height.

(To be continued)

DEEP DIGGER PLOUGH—FORD-RANSOMES

"ROTAVATOR" TRACTOR ATTACHMENT—ROTARY HOES

Dry Dock at North Shields

A LARGE dry dock, incorporating a number of unusual points of design, is to be constructed for Smith's Dock Company, Ltd., at its North Shields Works. The dock will have a length of 700ft, a breadth at the entrance of 95ft, and a draught on the sill 27ft at high water, ordinary spring tides. The scheme has been approved by the Lords Commissioners of the Admiralty as a much-needed addition to the drydocking facilities in this country for large vessels and, in particular, for the large oil tankers up to 30,000 tons deadweight, under construction or recently put into service, both in the United Kingdom and abroad.

A unique method is to be adopted in the construction of the dock walls by the use of steel sheet piles instead of the traditional mass concrete design. It is hoped that this method, which, so far as is known, has never been used before for a complete drydock, will considerably shorten the time of construction.

The dock will be equipped with modern electric cranes supplied by Stothert and Pitt, Ltd., and all the necessary services and facilities for ship repair. A "box" type flap gate, designed and constructed by Sir William Arrol and Co., Ltd., will be used for the dock. This gate will be fitted with a stainless steel and rubber seal instead of the usual greenheart, and it will be operated by a powerful electric winch. Its weight will be about 180 tons.

The main pumping plant for the dock will be installed by Drysdale and Co., Ltd., and will comprise two 39in motor-driven centrifugal pumps capable of emptying the dock in 2½ hours, together with the usual auxiliary pumps for dealing with ballast water, drainage, &c. A somewhat novel feature of this equipment will be the adoption of a siphonic system on the discharge side of the pumps in place of the usual sluice valves. Also the work will be constructed so that discharge water from the auxiliary pumps can be led through ducts under the dock sill for the purpose of preventing the accumulation of silt in the dock entrance. This arrangement has been adopted successfully in a number of recently constructed gates of this type.

The scheme also includes the extension of the existing deepwater quay from 500ft to 860ft, with a draught of 25ft at L.W.O.S.T., which will accommodate alongside the largest vessels coming to the port. A well-equipped platers' shed will be constructed at the head of the dock.

The whole scheme has been designed by Messrs. T. F. Burns and Partners, consulting engineers for the work. The contract for the constructional work has been placed with Holloway Bros. (London), Ltd., and it is expected that the work will occupy about 2½ years. A further development involving the closing of adjoining streets in the "Bull Ring" area at the north end of the works is to be carried out concurrently with the main contract.

ALUMINIUM ALLOY CASTINGS.—A Bulletin has recently been published by the Mond Nickel Company, Ltd., entitled "Aluminium Alloy Castings containing Nickel," based on a paper by Mr. F. Hudson. The casting alloys in use to-day are described, together with photographs of typical castings and tables give the mechanical properties and composition of aluminium-alloy castings for general engineering purposes (B.S. 1490 : 1949). A short section discusses casting quality and records, in tabular form, the properties of test bars cut from various alloy castings. Metallurgical developments are reviewed with special reference to melting practice, degasification, the use of fluxes, and methods of grain refinement, which are illustrated by macro-etched sections. The final chapter deals with production methods covering the selection of melting furnaces, pouring and running problems and notes upon casting by the gravity die, sand, pressure die and centrifugal methods. Information is listed concerning the aluminium alloys used for pressure die castings and also the standard heat-treatment schedules for a number of alloys. Copies may be obtained free from the Mond Nickel Company, Ltd., Sunderland House, Curzon Street, London, W.1.

Automatic Computing Engine (ACE)

DEMONSTRATIONS of a pilot model of the Automatic Computing Engine (known as ACE) were given last week at the National Physical Laboratory, Teddington, where the equipment was designed and built. The pilot model, besides serving as a basis for the ACE, which will be built later, is itself a complete computer, which has already been used for practical work and we learn that the superintendent of the Mathematics Division, National Physical Laboratory, will be glad to hear of industrial problems involving long and intricate arithmetical calculations.

The ACE is capable of tackling the computation work in any mathematical problem, and it is therefore more versatile than some similar machines which have been built to handle only one particular kind of recurring operation. For example, vital considerations in the safety of civil aircraft—such as the design of wings for a given loading, or the determination of their flutter characteristics—can, ultimately, be reduced to the solution of sets of simultaneous equations. The process of calculation involving, perhaps, fifty equations and fifty unknown quantities, would require six or seven months' work by a computer using a desk calculator. The same computation could be done on the ACE calculator in under 10 minutes.

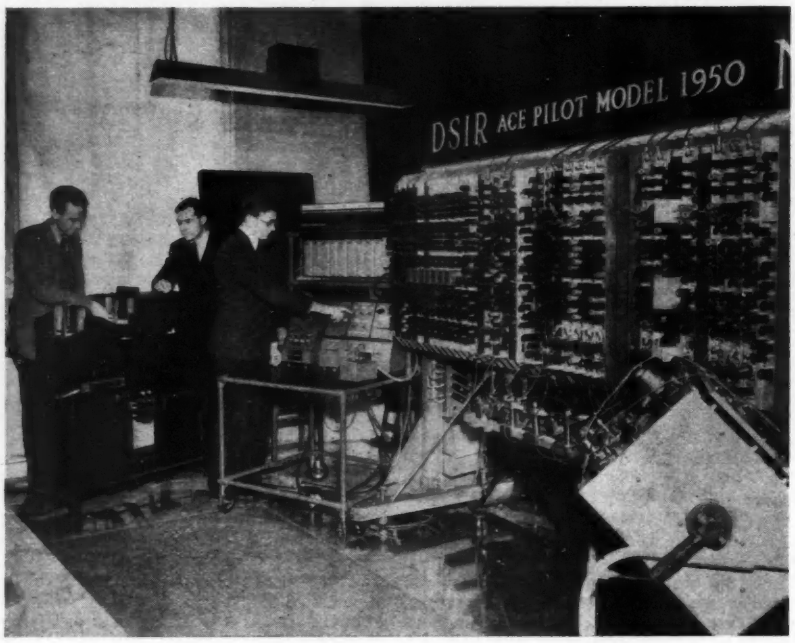
Optical work also offers a promising field of activity for the ACE. Thus, the art of designing a complex lens consists in making an informed guess as to what change in lens contour is likely to help and then working out the paths of the rays through the lens. If there are, say, ten refracting surfaces, the calculations may take about fifty-six working hours. In practice the process of trial and error is usually curtailed and the best solution is sometimes missed. The ACE has done calculations of this kind in less than 15 minutes. It should be appreciated that the instructions for making the machine do these calculations took about a week to make. However, the machine was then ready to work out any similar problem in lens design, using the prepared instructions.

Other likely uses for the ACE, and machines that may be developed from it, include the solution of electrical network problems, the preparation of radar navigational charts, surveying and crystallography. Crystallographers, for example, can often determine the structure of important substances, such as penicillin and vitamin B12, by a combination of mathematics and experimental work with X-rays; the mathematics, however, may involve some thousands of tedious calculations requiring months of work by a team of computers.

The ACE uses electrical pulses generated at a frequency of a million a second. In the machine the pulses represent the numeral 1 and the gaps between the pulses represent the numeral 0. All calculations are done with the help of these two numerals only, using the binary scale. Accordingly, when a sum is put into the machine the numbers must first be translated from the decimal scale into the binary scale; then, after completion of the calculation, the answer is retranslated into a decimal number.

Briefly, a programme of operations is given to the machine by coding the instructions in the form of holes punched in cards, the holes being used to make electrical contacts. For this purpose the cards are fed into a specially adapted Hollerith accounting machine connected to the ACE. The holes in the cards initiate momentary electric currents. These currents, in turn, release corresponding trains of pulses, which are distributed to "memory loops" in the ACE, where they are stored until the calculation is completed. When the ACE is loaded with numbers and instructions it begins the calculations, extracting the trains of pulses from the "memory loops," as required, and performing the necessary arithmetical calculations. The results of these calculations are passed back, in the form of trains of pulses, to the Hollerith machine, which punches another set of cards to correspond with the impulses it receives from the ACE. Finally, the punched holes are decoded into ordinary numerals. Although the ACE can only calculate in terms of binary numbers, it is completely versatile in that it can accept an input of numbers and instructions in either binary or decimal form and give its output in either form.

The "memory" element, mentioned above, is necessary to allow the machine to carry out long sequences of operations; it may, for example, have to combine the results of a dozen or more separate calculations and, since it can only do one computation at a time, it must "remember" each one until it is wanted. The storage of this information is achieved, briefly, by arranging that each electrical pulse train, representing a number, is shunted into a loop, comprising a supersonic delay line of mercury in a steel tube. At the incoming end of the delay line there is a crystal, through which the train of pulses is converted into corresponding supersonic signals and is passed along the mercury column. At the other end of the tube the pulses are amplified and fed back to the input end. The system forms a closed loop, around which the train of pulses circulates unchanged until wanted. Electronic relays at each end of the delay line allow the necessary switching to be carried out. Any number can be retained in one of these "memory" loops for hours, if necessary. If the same number is required at two stages in the calculation it can, in the first instance, release a copy of itself and then, by appropriate operation of the relays, the number can continue to circulate until it is wanted again. The "memory" capacity of the pilot computer is 8000 binary digits and the machine can deal with numbers up to nine decimal digits or the binary equivalent.



AUTOMATIC COMPUTING ENGINE, PILOT MODEL

A general view of the ACE is reproduced herewith. On the left is the Hollerith machine, which deals with the punched cards. In the centre is the control desk and, on the right, is the pilot model of the ACE itself. In this form the ACE consists, essentially, of forty-plug-in chassis mounted on a rack about 12ft long. A number of spare racks are provided, to allow for extensions of the scope of the machine. The mercury delay lines are supported on a rack, which is mounted centrally on the main board and below the row of plug-in racks, as shown in our illustration. At present ACE incorporates a total of about 800 valves, the power consumption being about 5kW, which is derived from a separate stabilised power pack.

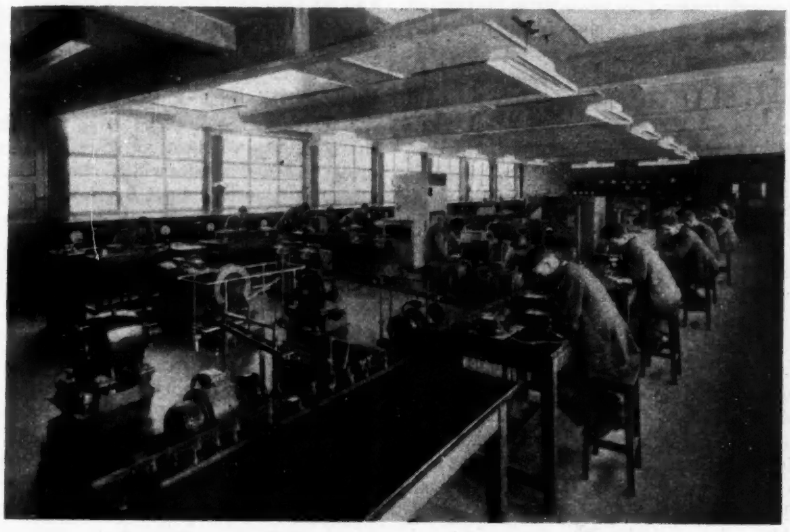
Rugby College of Technology and Arts

LAST week an interesting ceremony took place at Rugby College of Technology and Arts. On Tuesday, November 28th, there was formally presented to the College by the British Thomson-Houston Company, Ltd., a large amount of electrical laboratory equipment.

At Rugby for very many years there has been maintained a very close liaison between the local authority and engineering firms on matters affecting education. When, at the very beginning of the present century, the B.T.H. Company transferred its works from London to Rugby there was already a "Higher Education Sub-Committee" of the Urban District Council in existence; and at about that time it started single-subject evening classes in "borrowed" classrooms of existing schools. In 1919 there came into existence the Rugby Further Education Sub-Committee of the Warwickshire County Council. This body introduced planned courses of tuition bearing upon local industries under the ægis of the newly-designated Rugby Technical School. But classroom accommodation continued to present difficulties, and it became increasingly obvious that a special building would need to be erected. A new Mechanical Engineering Laboratory was completed in 1929. Meanwhile plans were being prepared for an entirely new College. In 1937 the first wing of this building was erected and by 1941 a substantial part of the whole building planned was already in use. The war then delayed further progress. But work is now proceeding upon further extensions. In 1948–49 the roll of students at the College totalled 2418, of whom more than one-half were taking engineering courses.

Over the whole of this period the B.T.H. Company took a great interest in the fortunes of the College; and in 1939 it promised to supply to the electrical laboratories all the

machinery necessary for such a purpose. Naturally, the war put a stop to the delivery of plant and post-war demands for electrical plant were so high that delivery of the promised machinery was further delayed thereby. But from time to time items of plant were delivered. Thus, some of the plant finally handed over on Tuesday of last week has actually been in use for some years. The choice of equipment and the lay-out of the laboratories expressly conformed to the particular end in view: that of bridging the gap between technical instruction in the College and practical training in the workshops of industry. It was therefore deemed expedient that the equipment should be industrial, as opposed to experimental—the kind that the student would meet



MACHINE LABORATORY, RUGBY COLLEGE OF TECHNOLOGY

in the outside world. In the machine laboratory, illustrated on this page, accommodation is provided for about forty students and, in general, each permanently located demonstration unit consists of a machine set or other power item together with a test table with terminal boards for instrument connections and an adjacent control panel fronting a continuous busbar chamber. The whole, as we were able to see for ourselves on the occasion of the presentation ceremony, provides a very convenient, indeed, a model, lay-out of plant for the purpose intended. In addition to this plant, the B.T.H. Company has also supplied to the College plant for a high-voltage laboratory.

At the presentation ceremony the chair was taken by Alderman W. S. Howard, Chairman of the Warwickshire Education Committee. The presentation was made by Mr. L. J. Davies, Director of Research and Education, of the B.T.H. Company, Ltd., who remarked upon the special interest continuously taken by that company in the training of craftsmen and engineers. The College had come into being because works training alone was not sufficient. Those who were being trained in engineering must have bookwork to learn the "know-why" as well as practical work to learn the "know-how." If good work was to be done at the College it needed skilled teachers and good equipment. It was for the latter reason that the company had presented equipment that had a net cost of many thousands of pounds—about £10,000 at pre-war prices. In accepting the equipment, Mr. W. Cooper, the Principal of the College, commented that until he came to Rugby he had little realisation how close co-operation could be between industry and education. Personal association between teachers and officers of the company were particularly valuable.

An address was then made by Mr. Tomlinson, Minister of Education, and the proceedings were brought to an end by a proposal of a vote of thanks to the Minister by Councillor Hobley, Mayor of Rugby.

Verein Deutscher Ingenieure Meetings in Frankfort

THE recent annual meetings of the Verein Deutscher Ingenieure, which took place in Frankfort, were the eightieth of their kind, and were attended by more than 1200 members from all parts of Germany. The Council met on Monday, September 4th, and the same evening an informal reception of members and guests was held in the Ratskeller in the Paulsplatz.

On Tuesday, September 5th, the first of the scientific meetings for the discussion of papers was held in the Frankfort University, and some eighteen papers were presented, dealing with workshop methods, industrial processes, motor-car manufacture, measuring and controlling methods and geared drives. In the course of the day various visits were made to engineering works in and around Frankfort, including the works of Hartmann and Braun A.G., Frankfort; the Frankfort Railway Repair Shops; Collet and Engelhard, Offenbach, and Voigt and Haffner, Frankfort.

On Tuesday evening a social meeting, taking the form of a "Frankfort evening," was arranged at the main restaurant in the Frankfort Fair Grounds, and greetings to the assembled guests were given by Dipl.-Ing. F. Voltz, the President of the Frankfort Branch of the V.D.I.; Dr. Walter Kolb, the Oberbürgermeister of Frankfort, and Dr. Magnus, the Hessen Ministerial Director for Work, Agriculture and Industry.

The principal meeting took place on Wednesday morning, September 6th, in the Franz-Althoff Hall at the Zoo, at 10.30 a.m., and it was preceded by a members' meeting. It began by the playing of the Beethoven Overture to "Egmont," by the Frankfort Opera and Museum Orchestra, conducted by Bruno Vondenhoff. The meeting was then officially opened by the President of the V.D.I., Director Hans Bluhm, of Düsseldorf, who spoke of the crying need for employment of the older engineers amongst their members, about 10 per cent of whom were unemployed. Many of these men, he said, came from the Eastern and other Zones, and deserved every sympathy. Having outlined the work of the past year, the President called on those who brought messages of greeting to the meeting, including the Oberbürgermeister of Frankfort, the Rector of Frankfort University, the Rectors of Darmstatt and Stuttgart Technical High Schools, the Chamber of Commerce of Frankfort, and allied scientific societies.

The President then invited Dr. Ing. H. C. Seebohm, the Minister of Transport, of Bonn, to deliver his lecture on "The Development of Technical Science and its Demands on the Engineer." He said that present-day conditions and the future of science called for strong leadership, and that there was a great need to seek to win men to new ideas of responsibility. The life work of the engineer was crowned by the gift of making new things. The engineer should have a real interest in life, and be prepared to help other men. After the lecture the orchestra played Mozart's Overture to "The Marriage of Figaro," and the President then read out the citations and distributed the honours, bestowed by the V.D.I. The "Grashof Medal" was given to Dr. Ing. E. H. Paul Reusch, of Kathrinenhof, who for forty years had guided the Gutehoffnungshütte to its leading position in foundry and steelworks practice, and the construction of machinery.

Honorary membership was conferred upon Herr Max Knoevenagel, of Hanover, who for nearly seventy years had been a member of the V.D.I. Hanover Branch and in his works had built up a business in woodworking machinery, boilers and containing vessels. Honorary membership was also given to General Director Dr. Ing. E. H. Carl Köttgen, of Berlin, who, since 1920 until his recent retirement was the managing director of Siemens Schückert Werke, Berlin. He was President of the V.D.I. from 1929 to 1931, and had much to do with the success of the second Berlin World Conference of 1930. Dr. Köttgen spent several years in England, before the 1914–18 war, and was the managing director of the Siemens Dynamo Works at Stafford.

The V.D.I. Mark of Honour was conferred upon Dr. Ing. Heinrich Maurach, of Frankfurt-am-Main, for his valuable research work in glass, and his organisation of the glass industry. A like honour was also given to Herr Gustav Windel, of Bielefeld, a leader in the textile industry and owner of the firm of Herman Windel G.m.b.H. V.D.I. rings were presented to four members: first, to Ministerial Director Dipl.-Ing. Leo Brandt, of Düsseldorf, physicist and short-wave investigator with the Telefunken G.m.b.H., who is now in the Ministry of Transport; secondly, to Dr.-Ing. Otto Cordier, of Köln, of the development section of Klöckner-Humboldt-Deutz, who introduced the air-cooled diesel engine for road transport; thirdly, to Dr.-Ing. Wilhelm Cornelius, of the M.A.N. bridge-building section at Gustavsburg; fourthly, to Director Erwin Menhofer, of Augsburg, a well-known textile engineer. It was announced that the Max Eyth prize for 1950 had been divided into five awards. After a few well-chosen words from the President, who thanked all who had made the Frankfort meetings such a success, the meeting was closed by the playing of the Overture from Wagner's Opera "Tannhäuser." In the evening a special performance of Strauss's Opera "Der Rosenkavalier," in honour of the V.D.I., was given by the Städtische Bühnen in the Börsesaal. On Thursday morning, reading of papers was continued in the lecture theatres of the Frankfort University; the programme included some twenty papers on power and heat, food machinery, technical history, heating and ventilation, and agricultural machinery.

Two public lectures were arranged. The first, on Wednesday, September 6th, was by Dipl.-Ing. Gartmann, of Landshut, on "Travelling in World Space: Its Possibilities and Limits of Technical Development." On Thursday, Dr. Ing. R. Feindler, of Bad Orb, dealt with "Competition between Means of Transport and Transport Problems in the Immediate Future."

The last day, Friday, September 8th, was devoted to a series of whole-day excursions, and among the places visited were the works of Carl Schenck G.m.b.H. Darmstadt, the Technical High School, the Shoe Factory of Carl Freudenberg, Heidelberg Castle, the factory of Ernst Leitz at Wetzlar, the Opel Works, Rüsselsheim, and the V.D.M. works and the M.A.N. works at Mainz-Gustavsburg. There was also a Rhine steamer excursion to Coblenz.

SPOT WELDING OF LIGHT ALLOYS.—A review of published information on the spot welding of light alloys is contained in the October issue of the journal of the British Welding Research Association. It summarises the various kinds of spot welding machine, and their characteristics.

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NOTICE TO READERS

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THE COLOMBO PLANS

SELDOM does a White Paper bring out so effectively the great value of the work of engineers to a community as the one that lies before us as we write. It is the report by the Commonwealth Consultative Committee on the "Colombo Plan" for co-operative economic development in South and South-East Asia. That report has been issued as a consequence of the meeting in Colombo last January, of the Foreign Ministers of the various Commonwealth countries. There they agreed upon "the vital importance of the economic development of South and South-East Asia in the maintenance of the political stability of the countries in that area and in the growth of an expanding world economy based upon multilateral trade." The region with which the report is concerned contains 570 million people, about one quarter of the total population of the world! It covers India and Pakistan, Ceylon, Malaya, British Borneo, Burma, Thailand, the Associate States of Cambodia, Laos and Viet-Nam, and Indonesia. The area, it will be seen, extends beyond the boundaries of the Commonwealth. But, unfortunately, in the time available, non-Commonwealth Governments who were invited to contribute to the plan, were unable to formulate full programmes. The report is therefore almost wholly confined to Commonwealth affairs, although it is hoped that figures for other areas will soon become available. But since about three-quarters of all the inhabitants of the region live within the Commonwealth it is possible without serious inaccuracy to estimate from the report the needs of the whole. Though in carrying out the works envisaged under the plan those expert in many sciences, arts and techniques will be called upon to play their parts, the report makes it abundantly clear that the main work to be done can be done only by engineers.

The populations of South and South-East Asia lie for the most part under miserable conditions, closely comparable with those imagined by Malthus. In the past, even in the recent past, the population has only been restrained from expansion by wars, famines, pestilence and other disasters. To this day the diet of the peoples lacks the variety necessary for proper nutrition and the quantity consumed, valued in calories, falls by some 30 per cent below that regarded as necessary for healthy life in the United Kingdom. Malthusian conditions continue to rule to this day. For the beneficent work of doctors, engineers and others (in, for instance, eradicating malaria from Ceylon, in increasing irrigated areas and improving food supplies, improving possibilities of transporting food from areas with bumper crops to those suffering from drought or disease and other developments that in the West have contributed to the enrichment of peoples) threaten to prove nugatory in the East. The population is increasing at such a rate that the present 570 millions will reach 720 millions in 1970 at present annual growth rates, and if the development of the areas concerned is not brought about sufficiently rapidly standards of living, instead of rising, will fall. As the report puts it, "the problem may be described as one of increasing the capital equipment of the countries in order not only to keep pace with the growth of populations, but also through increased production per head, to permit some rise in the level of consumption." In fact, in helping the East to develop the very large human and material resources that are available, once basic services such as railways, roads, harbours, electricity, irrigation, &c., have been provided, the West is called upon for an act of faith. For the whole effort will have been wasted and will achieve nothing if the higher standards of living it brings about are rapidly rendered nugatory by expansion of population.

In carrying out the plans outlined in this report, doctors, sociologists, agriculturalists, biologists, financiers, economists, and many others expert in their own fields, must be included. But basically the plans are engineering ones. Expenditure upon "agriculture" (which covers irrigation and power schemes), transport, communications and electric power, accounts for more than 70 per cent of the total cost. The peoples of the regions concerned are to benefit from the turning of the forces of Nature to their use. In India, for instance, by far the greater part of the expenditure will be used to provide improved transport and to construct great power and irrigation schemes, such as those in the Damodar valley, on the Mahanadi at Hirakud, and on the Sutlej. Between them those three projects alone are expected to irrigate some six million acres of new land and to increase generating capacity by 708,000kW. For, in fact, it is engineers, and engineers alone, who can really show whole peoples how to increase their own productivity and thus how to raise their standard of life. It is the engineers who bring water to make deserts flourish and who build the railways and the roads that carry away the produce and bring in the tools and the fertilisers that can increase output still further; and it is the engineers who can provide the mechanical power without which the output of human labour is limited by sheer muscular endurance. The more highly developed nations of the Commonwealth and the world can, and we hope will, help by providing capital for the construction of such great works in under-developed regions. Yet it is inherent in engineering knowledge that those who have learnt it can improve their standards of life by pulling themselves up "by their own bootlaces." Britain, no doubt, as the leading industrial nation in the Commonwealth, will provide much of the equipment needed and make available financial services. But its greatest and most beneficent contribution will lie in extending the facilities it already offers for young men from the Commonwealth to come to this country and learn "how" and "why"; and in lending her sons, skilled in the engineering and other problems involved, to the services of the less-developed nations. White Papers usually make dry reading. The one that is before us is no exception. Yet any engineer who peruses it and studies it without experiencing an uplifting of the heart and a renewal of enthusiasm for his work must, we think, be sadly lacking in imagination. Under the present disturbed conditions of the world engineers are looked to by the nations to create armaments and weapons of destruction. But the Colombo proposals constitute beneficent tasks far closer to their hearts.

A GREAT SIGNALLING SCHEME

AT the weekend of October 7–8, 1950, colour light signalling was installed on the London Bridge main line of the Southern Region, Central Section, between Bricklayer's Arms Junction and Norwood Junction North, as described in our issue of November 17th. This replacement of semaphore signalling controlled by Sykes lock-and-block on a stretch of 6 miles of quadruple-track main line, interesting and important though it is in itself, is only the first stage of a great scheme of signalling modernisation which is programmed for completion within the next five years, and which, it is expected, will cost something in the region of 1¾ million pounds. Re-signalling of the Central Section lines of the former Southern Railway—the old London, Brighton and South Coast Railway—has been carried out to meet the

requirements of increased train service consequent upon electrification. London Bridge, a terminus as far as the Brighton system was concerned, was completed first, in 1928; the country section, from Coulsdon southwards, followed in readiness for the inauguration of electric traction to Brighton itself in January, 1931. Here, as described in THE ENGINEER, May 20, 1949, considerable operating economies were effected, since with the new arrangements five signalboxes were able to deal with traffic previously requiring twenty-seven. In succeeding years the Western Section of the Southern Railway came in for attention as far as resignalling was concerned, to deal with the electrification of the main line to Portsmouth. In the meantime the intense traffic of the Central Section north of Coulsdon, including the second great terminus, Victoria, was still handled by Sykes lock-and-block and semaphore signals. Modernisation in this respect began early in 1939, when Victoria Station and its approach lines were changed over to colour lights, with continuous track circuiting, but the outbreak of war in 1939 had the effect of postponing indefinitely the work of linking up the three installations—London Bridge, Victoria and the Coulsdon-Brighton stretch. This is the task upon which work has now started.

A total of 21 route miles is involved, all quadruple-tracked: from Bricklayer's Arms Junction, through Croydon, to Coulsdon; and from Pouparts Junction (between Battersea Park and Clapham Junction) to the point of convergence with the London Bridge line on the outskirts of Croydon. Extensive and intricate work is involved, particularly at East Croydon. But the Southern Railway, to a greater extent perhaps than any other of the pre-nationalisation "groups," had evolved a standardised signalling technique that enabled each successive scheme to be taken in its stride. The difficulties in the present scheme are likely to arise more from the heavy pressure upon the engineering industry as a whole, precluding swift delivery of much material required, and from the shortage of labour. In this respect the actual installation work, as always on the former Southern Railway, is being carried out by the railway staff. In previous years we have seen something of the organisation of the Signal Department, built up under the direction of the late Colonel G. L. Hall, Assistant Engineer, Signals and Telegraphs, and later designated Signal Engineer, from 1927 until his death in January, 1947, and there was indeed something of military precision not only in the installations themselves, but in the closely detailed manner in which preparations were made for changing over from manual to colour light signalling. By the use of temporary control apparatus most of the electrically operated points were brought into service before the change over day, and worked from the old mechanical frames. Thereby all the troubles of hastily changing over the physical attachments to the switches on "opening night" were avoided, and the process of change over, so far as points were concerned, involved little more than removing the fuses from one circuit and inserting them in another.

The new work recently brought into service may be described as a characteristic piece of modern signalling. There are some notable improvements in detail, in the handsome appearance of some of the signal structures, and a novelty in the illuminated diagram at Forest Hill. Otherwise the established signalling practice of the Southern Railway is followed. Three new interlockings, controlled by power frames with all-electric lever interlocking have been put into commission at Bricklayer's Arms Junction, New Cross Gate, and at Forest Hill; they replace eight old boxes and show a reduction in levers from a previous total of 279 to a present one of 147. But from details of this scheme, or indeed of the final link-up programmed for 1955, one turns to contemplate the overall picture which the signalling of the old Brighton main lines will then present. Hitherto the application of power signalling in this country has been made at centres of intense traffic, to assist in dealing with a local problem. On the Central Section of the Southern, however, quite apart from the special work on the Brighton main line, all sizeable traffic centres, such as Lewes, Dorking, Horsham, Bognor, will be fully track-circuited, though the traffic has so far not justified the use of continuous colour-light signalling on the Mid-Sussex line to Bognor and Portsmouth, or on the Eastbourne route. Nevertheless, the spectacle of so extensive, and so heavily worked, a network of electrified main lines equipped from end to end with thoroughly modern signalling, will afford opportunities for close study of the art of passenger traffic handling.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

STANDARD LOCOMOTIVES

SIR,—I hope that the British Railways will be able to introduce either a 4–8–4 or a 4–8–0 of between 45,000 lb tractive effort to 48,000 lb with 74in wheels: a simple version of P.O. 4–8–0, in fact, and as useful for fast freight work as for passenger work. If ever the 600-ton trains to Scotland are introduced, these would be the engines to do the job. And may I ask which of the stations on the East and West Coast routes have platforms long enough to take such trains? The S.R. could also use such engines to Dover and from Salisbury to Exeter, as well as freight trains from Southampton. Another design is a 63in version of the Stanier 2–8–0 for use over the Highland lines and over the Somerset and Dorset, especially if given a pressure of 250 lb; much better than the 5P 4–6–0 at present in use over them. There is no call for high speed, but for power in climbing.

EDW. H. JOSLIN

Port Lincoln, October 24th.

SOME AMERICAN LOCOMOTIVES AND THEIR RUNNING

SIR,—In reply to Mr. Leedham, I have to say that published figures show the overall efficiency of American steam locomotives to be comparable with that of British locomotives; it is expressed by a coal consumption of about 3 lb per drawbar horsepower hour when developing about 30 drawbar horsepower per square foot of grate area.

American locomotives are, however, habitually worked at higher rates than this and coal consumption may go up to 5 lb per d.h.p.-hour at 50 d.h.p. per square foot, which is the usual British maximum for periods up to about ten minutes. Some overall efficiency figures quoted for American locomotives are appreciably higher than any recorded in this country but I find difficulty in regarding them as the effect of differences in design and operation is in the opposite direction.

Basic design of locomotives in America is not, in my opinion, markedly ahead of British practice. The main advantage of the modern American steam locomotive is that its detail design makes servicing quicker and easier than here. Rocking grates, bottom-discharging ashpans and grease lubrication permit servicing to be effected without removing the engine from the train. Continuous run of about 1000 miles have thus been made practicable.

Less attention has been paid in America to attainment of high thermal efficiency than has been the case here. The essential there is the ability to withstand hard work at high speed with the late cut-off that is necessary to use the full boiler output in the relatively small cylinders. The New York Central 4–6–4s, for example, regularly cover 200,000 miles of hard running between major repairs.

The training of an "engineer" (driver) proceeds on substantially the same plan as is common here except that the initial period engaged in cleaning is usually omitted. Despite their large size, American locomotives are no more difficult to handle than our own.

My impression is that division of the drive between four cylinders (as in the Pennsylvania T.1 and Q.2 classes) is regarded as barely justifiable.

W. A. TUPLIN

Huddersfield, November 20th.

SAFETY IN INDUSTRY

SIR,—I read Mr. B. C. Robinson's letter about portable electrical tools with particular interest, because I have vivid recollections of a workman being electrocuted whilst using a portable electric drill plugged into the 230V a.c. supply. Fortunately, the safety rules followed in this country are such that fatalities of this nature are extremely rare.

Undoubtedly a limitation of 110V has much to recommend it, and I sometimes wonder whether the cost of electrical installations would be less if the lower voltage were standarised in this country as in the U.S.A. I have recently had occasion to install flameproof electrical equipment for 230V and the cost of this work is a very considerable proportion of the total capital outlay. It is clearly out of the question to make any countrywide change in the standard voltage, but Mr. Robinson's suggestion for the use of double-wound transformers will receive careful consideration in any similar schemes which I may have to handle in future.

K. ARTER, M.I.Mech.E.

Harwell, Berks, December 1st.

BOOKS RECEIVED

Radar Systems and Components. London: Macmillan and Co., Ltd.. St. Martin's Street, W.C.2. Price 56s.

Modern Railways. By Brian Reed. London: Temple Press, Ltd., Bowling Green Lane, E.C.1. Price 8s. 6d.

Manual of British Water Supply Practice. Editor, Aubrey Thomas Hobbs. London: The Institution of Water Engineers, Parliament Mansions, Victoria Street, Westminster, S.W.1. Price 50s.

Stress and Strength of Manufactured Parts. By Charles Lipson, G. C. Noll and L. S. Clock. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 38s. 6d.

Diamond Tool Patents; Truing of Grinding Wheels. By W. Jacobsohn. London: Industrial Distributors (Sales), Ltd., 32–34, Holborn Viaduct, E.C.1. Price 7s. 6d.

Hydraulic Diagrams: No. 3, Design of Surface Water Sewers Frequency of Rainstorms. London: Contractors' Record, Ltd., Lennox House, Norfok Street, W.C.2. Price 3s. 6d.

Obituary

PERCY GOOD, C.B.E.

In all branches of the engineering profession the death of Mr. Percy Good will be keenly regretted. It occurred, after a short illness, at his home, 1, Vincent Square, London, S.W.1, on Saturday last, December 2nd. There has thus been brought to an end a long and distinguished career with the British Standards Institution, of which Mr. Good was the Director.

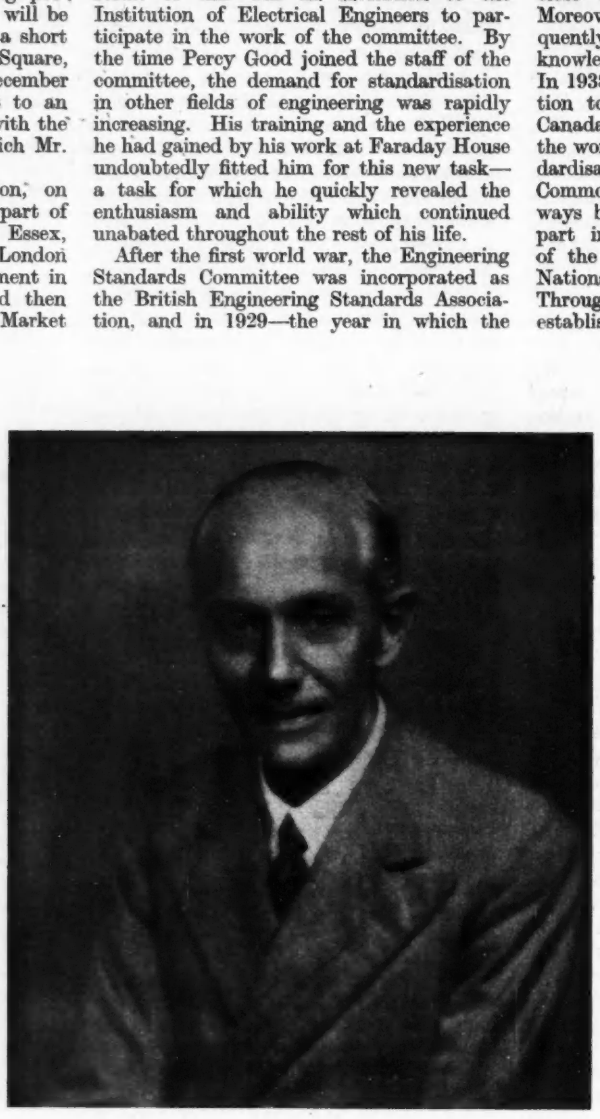
Percy Good was born in London, on November 5, 1880. For the earlier part of his education he attended Ongar, Essex, Grammar School and the City of London School. He left the latter establishment in 1897, at the age of seventeen, and then spent a few months in the Smithfield Market electricity supply station. But the engineer of that station urged Good to take an electrical engineering course. The advice was accepted and he became a student at the Central Technical College. His course there was completed in 1900, in which year he obtained the College Diploma in Electrical Engineering. On leaving the "Central," Percy Good joined the electrical engineering department of the Thames Ironworks, Shipbuilding and Engineering Company, Ltd., and served for six months as an assistant electrician. He was then transferred to the testing shop of the Thames Ironworks and for some time took charge of that department.

After leaving the Thames Ironworks, Mr. Good took up an appointment at Faraday House, Southampton Row, London, under the late Dr. Alexander Russell. That establishment was at the time described as an Electrical Standardising, Testing and Training Institution, and in 1905 Percy Good became superintendent of the testing department. He left Faraday House a year later, however, and started a consulting engineering practice. His work for the most part was concerned with specifying electrical installations in private houses, country mansions and institutional and other public buildings. He was also frequently called upon to inspect machines and materials for export.

It was in 1913 that Mr. Good began his long and close association with the organisation which is now known as the British Standards Institution. In that year he was appointed assistant secretary to the Engineering Standards Committee. It is not without interest to recall that the Committee was originally constituted in 1901 by the Institution of Civil Engineers, to consider the standardisation of iron and steel sections. At the first meeting it was decided to invite the Institution of Mechanical Engineers, the Iron and Steel Institute and the Institution of Naval Architects to nominate representatives to the committee. But it soon became evident that the need for standardisation was realised by a large section of the engineering community and before the end of its first year the committee was asked to deal with the standardisation of locomotives and the testing of engineering materials. Early in 1902 there was a further development of the work when the Engineer-in-Chief of the Post Office urged the committee to undertake the standardisation of electrical plant. The result of this was an invitation to the Institution of Electrical Engineers to participate in the work of the committee. By the time Percy Good joined the staff of the committee, the demand for standardisation in other fields of engineering was rapidly increasing. His training and the experience he had gained by his work at Faraday House undoubtedly fitted him for this new task—a task for which he quickly revealed the enthusiasm and ability which continued unabated throughout the rest of his life.

After the first world war, the Engineering Standards Committee was incorporated as the British Engineering Standards Association, and in 1929—the year in which the B.E.S.A. was granted a Royal Charter—Mr. Good was appointed deputy director. By then the demands for standardisation were becoming so insistent from other industries that "Engineering" did not wholly describe the functions and growing responsibilities of the Association. Consequently, the present title, British Standards Institution, was adopted in 1931. In the first half-century of its existence the half-dozen technical committees which initiated the work of standardisation has increased to something like 2000 technical committees, each of which is responsible to one or other of the fifty industry committees. The work of all those committees has been made the more valuable by the guidance and advice that Mr. Good was at all times ready and able to offer. When Mr. le Maistre retired in 1942 Percy Good was most appropriately appointed to succeed him as Director of the Institution.

By far the greater part of Mr. Good's career, therefore, was devoted to furthering the work of standardisation in the engineering and other industries. But the influence of that work was not restricted to this country. All the nations of the British Commonwealth have set up standards organisations similar to the B.S.I. and work in close collaboration with that Institution. Moreover, those organisations have frequently benefited by Mr. Good's thorough knowledge of all aspects of standardisation. In 1938, for instance, he accepted an invitation to visit Australia, New Zealand and Canada to discuss certification marking and the work of standardisation generally. Standardisation in countries beyond the British Commonwealth was also assisted in many ways by Mr. Good. He took a prominent part in the formation, towards the end of the second world war, of the United Nations Standards Co-ordinating Committee. Through that committee there has been established the International Organisation for Standards, in the work of which no less than twenty-nine member countries are now participating.



PERCY GOOD

Whilst Percy Good will, naturally, be best remembered by his work for the British Standards Institution, it is fitting that his service to other institutions and organisations should be put on record. He was elected to associate membership of the Institution of Electrical Engineers in 1905, and to full membership in 1912, serving subsequently on many of the Institution's committees. In 1942 Mr. Good was elected a vice-president of the Institution, and in 1947 he succeeded to the presidential chair, his address, delivered in the autumn of that year, being devoted to the subject of industrial standardisation. In that address he not only reviewed the history of the organisation which he so ably directed, but emphasised the need for and the usefulness of standardisation. For some years prior to his presidency, he had regularly contributed to the Proceedings of the Institution annual progress reports on electrical standardisation. Mr. Good was also actively interested in the work of the Illuminating Engineering Society, and served for a term as its president. During the second world war, the Illuminating Engineering Society collaborated with the Ministry of Home Security in the setting-up of a joint lighting committee. Mr. Good did valuable work as chairman of that committee, a work which was recognised by the award of the C.B.E. in 1945. Other directions in which Mr. Good's counsel was at all times welcomed were on the management board of the Regent Polytechnic, of which he was a member, and on the executive committee of the National Physical Laboratory. In addition, he was an Honorary Fellow of the Imperial College of Science and Technology and a member of the Basic English Trust.

Almost to the end of his life, Percy Good was energetic in and enthusiastic about the manifold activities of the British Standards Institution, which he had served so well for thirty-seven years. By all who came into contact with him—in this country and overseas—through that and other organisations with which he was associated, he will be deeply mourned.

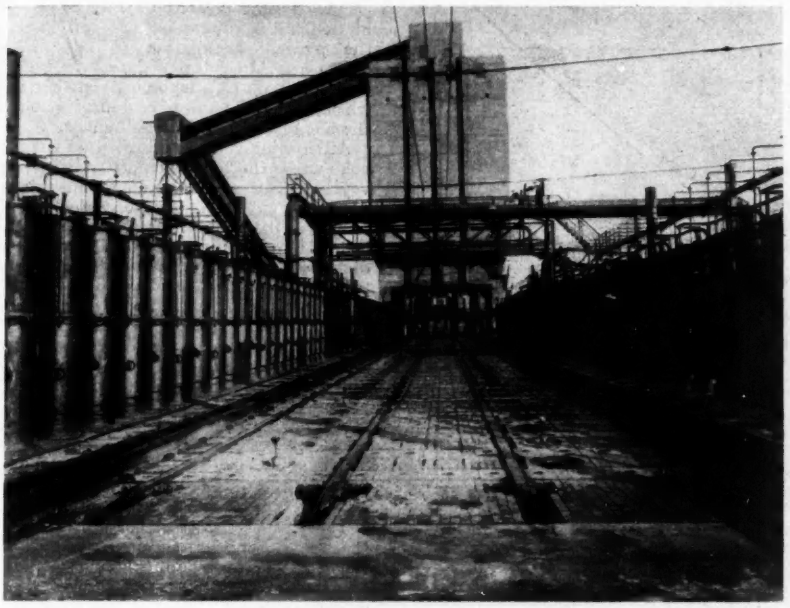
Extensions at East Greenwich Gasworks

A LARGE new coke oven plant was inaugurated at the East Greenwich works of the South-Eastern Gas Board by the Duke of Gloucester on Thursday, December 7th. This new plant forms part of a scheme started by the former South Metropolitan Gas Company for the systematic replacement of obsolete equipment by an installation of coke ovens and ancillary equipment of modern design. The scale of manufacturing operations at the works offered wide scope for modernisation, and it was decided to install coke ovens as the most suitable form of base load plant and to adopt water gas generation to obtain the flexibility of output necessary to meet the daily and seasonal fluctuations in the public demand for gas.

Considerably extended auxiliary services were needed in order to provide for the high throughput of 1000 tons of coal per day. The lay-out of the plant provides for a duplication of this installation on the north side of the service bunker at one end of the ovens.

The ovens are built on a reinforced concrete decking, supported by columns carried on a reinforced concrete raft. The substructure so formed accommodates the fuel-gas distributing mains and the reversal equipment. In the decking the transverse beams are extended at each side to provide supports for the buckstays on which the gas collecting mains, liquor and steam pipes are carried. Reinforced concrete retaining buttresses built at the ends of each battery are designed as beams, cantilevered from and monolithic with, the foundations.

The reinforced concrete service bunker, which holds 3000 tons of coal and will ultimately serve



TOP OF THE COKE OVENS

degree of mechanisation incorporated in this major engineering project. For these services the following installations have been introduced:—A power-house covering the initial demand for 2000kW, with provision for future developments; twelve waste heat boilers to supply steam for the power-house and other plant; a river water pumping system supplying 600,000 gallons per hour, providing cooling water for condensers and for gas cooling; an artesian well supplying 20,000 gallons of water per hour for the boilers; a new coal and new coke-handling plants; a producer gas plant for generating cold clean gas for heating the coke ovens; and a wet purification plant for cooling and cleansing of coal gas from the coke ovens.

When the new plant and ancillaries were being planned an increase in the manufacturing capacity of the works to 70 million cubic feet of gas per day was envisaged. Hitherto the gas-making capacity of the works has been 34 million cubic feet of gas per day, and it was produced by the carbonisation of Durham coals in horizontal retorts.

Reinforced concrete has been largely used in the construction of the new plant, and the heavy structures are carried on cast-in-situ piles. As the ground water has a high sulphur content, sulphate-resisting aluminous cement has been used for all concrete placed below ground level in order to avoid the risk of disintegration.

The two batteries of coke ovens, each of twenty-two ovens, were constructed by Simon Carves, Ltd., and are designed for a total eighty-eight ovens when the plant is extended, has a deadweight when empty of approximately 6100 tons. It is supported on two reinforced concrete beams, 8ft in depth, each of which is carried on 186 piles. Coal is withdrawn from the base of the bunker through discharge gates, set at a sufficient height to permit a charging car to pass beneath. An electric interlocking system between the discharge gates and the travelling motor of the charging car immobilises this car if any gate is not securely closed. The desired coal charge is obtained by adjustment of measuring sleeves, at the top of each of four funnels of the charging car. Each charge is weighed before the car travels along the top of the oven battery to take up a position to fill, by gravity, the required oven through four charging holes in the oven top. After an oven has been charged the coal is mechanically levelled by a levelling bar on the ram machine. Each charge of coal weighs approximately 14½ tons. In one of the photographs reproduced, showing the top of the ovens, the charging machine can be seen in the background being loaded from the service bunker.

The carbonising period of 15½ hours entails the charging and discharging of one oven every twenty-one minutes. At the end of the carbonising period the doors at each end of the oven are removed by power extractors, and the coke is pushed out by the electrically operated ram, shown in another of the illustrations. A coke car receives the hot coke discharged on the opposite side, and an electric locomotive propels the car, with its charge, to the quenching tower, where the contents are cooled in about one minute by a shower of 5000 gallons of water. The quenched coke is afterwards spread on a sloping wharf to cool and dry before being delivered by belt conveyor to the coke-handling plant.

The gas leaves the ovens through ascension pipes and collecting mains on both sides of the batteries. The ascension pipes, which are 15in in diameter within their refractory linings, are connected at their tops to the collecting mains by special pipes fitted with isolating valves, which are used to seal off the ovens during charging operations. At this stage the gas is initially cooled by a spray of ammonia liquor, the total amount of flushing liquor used on the two batteries being about 80,000 gallons per hour. The collecting mains enter a common 54in diameter main, which carries both the gas and the flushing liquor to the wet purification plant.

The principal dimensions of each oven are as follows:—

Length over sole	44ft 7½in
Height of chamber	12ft 6in
Width of oven chamber:	
Ram side	1ft 3in
Coke side	1ft 5¾in
Length of charge	41ft 7½in
Height of charge	11ft 4½in
Volume of charge	618 cubic feet

The twin-flue compound type ovens are normally heated by producer gas, but underjet firing is employed when using coal gas as fuel. In the twin-flue—or "hairpin"—flue arrangement the heating gases pass up one flue and down the next flue in the same oven wall, there being a very short portway connecting the tops of each pair of flues. In a "compound" oven provision is made to burn "rich" coal gas or "lean" producer gas.

When firing with producer gas (lean gas) the gas and air ascend separately in neighbouring regenerators and during their passage are preheated to 1000 deg. Cent. Oblique ports divert the gas and air to the base of the wall flue, where combustion takes place and the hot gases pass upwards over the hairpin flue and descend through the next wall flue, thence by another pair of ports to the tops of the adjacent regenerators. At this stage the temperature of the waste gas is 1100 deg. Cent. but, as it flows downwards through the waste gas regenerators, it gives up its heat to the fillings, leaving the base of the regenerator on its way to the chimney flue at a temperature of 250 deg. Cent. Reversals of flow, taking place at intervals of thirty minutes, are effected by electrically driven reversal winches, automatically operated by a master clock. By the arrangement adopted, when reversal takes place a regenerator chamber, which has been receiving heat from the hot waste gases discharging through it in a downward direction, imparts heat to the cold air or gas flowing upwards to the flues.

Normally, the ovens are heated by producer gas generated in six "Marishcka" producers supplied by Humphreys and Glasgow, Ltd., five producers being designed to carry the load with the sixth in reserve. The "Marishcka" producer was installed because it generates high-pressure steam in large quantities at the standard pressure of 160 lb per square inch used in the works' waste heat steam-raising plant. Each producer consists of two annular vessels, arranged coaxially one above the other, connected by a nest of 180 3in diameter tubes, 2ft in length and arranged in three concentric rings. The diameter of the centre shell is 8ft and the fuel bed is contained wholly within the lower vessel. The supply of fuel is so regulated that the level of the top of the fuel is always maintained below the top of the lower section of the boiler. The hot producer gas rising from the fuel bed has to pass more or less radially through the spaces between the tubes into an outer annular jacket. The inner surface of the jacket also forms the outer shell of a boiler and gives additional heating surface. The gas travels round within the annular jacket to the main outlet, whence it passes into a rectangular steam superheater containing a fourfold nest of tubes. The total heating surface of the boiler is

some 660 square feet and that of the superheater 240 square feet.

Each of the producers is rated to gasify 25 tons of coke per day, graded 1in to 2in, and to generate 5400 therms of producer gas at a calorific value of 125 B.Th.U. per cubic foot, i.e., about 4¼ million cubic feet per day. During this period it provides some 70,000 lb of steam at 160 lb per square inch and 500 deg. Fah. superheat. Each producer has its own scrubbing unit, consisting of an unpacked spray tower, a shallow layer of Raschig rings at the top acting as a spray arrester.

Coke supply for the producers is delivered by belt conveyors to overhead hoppers, from which the feed to the producers is automatic, a predetermined volume of coke being admitted through a sealed feed chamber at regulated intervals.

The air blast to the producer grates is saturated to the required temperature by the controlled addition of exhaust steam. The air blowers to the producers and the boosters handling the producer gas are duplicated and are normally driven by electric motors; steam turbine-driven sets installed as standby come into operation automatically in the event of failure of electric power.

The cooled gas leaving the scrubbers is finally cleaned from dust and tar fog in plate type electrostatic precipitators erected on the roof of the machinery house. To make the precipitated tar more fluid and to aid its flow from the electrodes a tar oil is evaporated into the gas at the outlet of the scrubbers.

To control the pressure of the producer gas at the coke ovens two Foxboro Yoxall controllers have been installed. One controller operates on the pressure of the air supply to the producers and is actuated by the pressure at the producer top, and the other operates on the pressure in the main supplying the ovens and is controlled by the pressure in that main. During the flow reversal at the ovens the demand for producer gas falls to 50 per cent for a short time four times per hour, when two coke oven batteries are set to a reversing cycle of thirty minutes.

The principal units of the condensing, gas cleaning and washing plant erected by Whessoe, Ltd., are arranged in the following sequence:—Five primary condensers, three turbo-exhausters, five secondary condensers, four electrostatic detarrers, six static ammonia washers, two "Connersville" meters, and two gas heaters.

The plant is divided into two streams, either of which is capable of treating the gas from forty-four ovens. Two primary and two secondary condensers only are needed to each stream and the fifth condenser can be used as a standby in either stream. Each of the three turbo-exhausters is capable of handling the gas produced in forty-four ovens.

The condensers, detarrers and the exhauster house have been erected on a reinforced concrete elevated platform supported on piers, and the space beneath the platform has been enclosed and partitioned to house the necessary auxiliaries, pumps and switchgear.

The turbo-exhausters, which were designed and built by Bryan Donkin and Co., Ltd., are driven by direct-coupled Brotherhood turbines and have a speed range from 6800 r.p.m. to 8400 r.p.m. These turbines work at 25 lb per square inch back pressure and their exhaust steam is used in the producer plant for saturating the air blast. The secondary condensers on the outlet side of the turbo-exhausters are of a greater height than the primary condensers on the inlet side and cooling water leaving the secondaries flows by gravity to the primary condensers. The flow of water is automatically controlled to maintain a gas temperature of 40 deg. Cent. at the inlet to the exhausters.

Splitting the condensing in this way has made possible the use of small exhausters and gives a lower power consumption than would have been required if all the condensing was performed on the outlet of the exhauster. At the same time, the arrangement permits the removal of the heat imparted to the gas by compression in passing through the exhausters. All condensers are so designed that the gas passes can be flushed with tar to remove naphthalene deposited in the cooling process. These condensers, of the multitubular, multipass design, are of welded construction throughout.

The static ammonia washers use softened water to prevent the blockage of the fillings which would otherwise occur as a result of the interaction between ammonia and hard water. Catch tanks installed for the collection of flushing liquor and condensate hold about 30,000 gallons at working level and are divided into three passes to give good separation of tar and liquor.

Heaters through which the gas flows after passing through meters on the outlet side of the washers warm the gas sufficiently to prevent condensation or deposition of naphthalene in an overhead main leading to the oxide purifiers.

RAM MACHINE DISCHARGING COKE

Coal and Coke-Handling Plants

With the exception of the hydraulic cranes and receiving hoppers on the jetty, the plant used in the new coal-handling system was erected by Sovex, Ltd. Coal is removed by belt conveyors from the two sets of receiving hoppers and transferred to a single-belt conveyor, feeding a screening and crushing plant. This plant, which is situated inshore over a transfer hopper of 90 tons capacity, effects a size reduction to 2in.

From the 90-ton transfer hopper coal can either be dispatched by rail to the retort houses or stockpiles in the coalfield or be fed to a conveyor belt for delivery to the blending bunkers. The capacity of this conveyor system is 400 tons per hour and all coal handled is automatically weighed at various points in the system. The coal-blending plant consists of six reinforced concrete vertical cylindrical bunkers, each 32ft in diameter, 74ft high, and of 1200 tons capacity. The speed of each bunker withdrawal belt can be regulated by means of variable gears to give discharge rates from 40 to 150 tons of coal per hour. Coal flows from the withdrawal belts to a common collector belt, which delivers it to the secondary crushers. These crushers were supplied by the British Jeffrey Diamond Company; each has a capacity of 150 tons of coal per hour and gives a size reduction from 2in. to below ½in.

From the secondary crushers the coal is elevated by belt conveyors to the top of the coke oven service bunker at the rate of 150 tons per hour. The capacity of these conveyors will be doubled by increasing the belt speed when the present installation of coke ovens is extended. At the top of the service bunker the coal passes on to a revolving shuttle conveyor, which directs the flow of coal into any one of the three compartments of the bunker.

After being cooled and dried on the inclined coke wharf the coke is transferred by belt conveyor to a cutting and grading plant supplied by Simon-Carves, Ltd. The ungraded coke is fed to a 3in. grizzly screen, from which the oversize is loaded by gravity into railway wagons or diverted to a cutter. Coke passing through the first grizzly screen falls on to a second unit, which separates material below 2in. Provision is made to allow 50 per cent of the coke between 2in and 3in to be diverted to the cutter; alternatively, the whole of this grade can be carried by belt conveyor to the appropriate hopper on the storage plant. The cut coke is added to that which has passed through the 2in grizzly screen and the combined stream carried by belt conveyor to the grading plant, where "Gyrex" screens grade the material and separate it into four sizes.

The various grades of coke are loaded from the storage hoppers through side chutes into railway trucks or by adjustable feed trays on to a belt conveyor. This conveyor delivers the coke to coke sales hoppers, the producer plant and the water gas plant. The conveyor will also be used to feed a boiler-house to be built at some future date. With the exception of the conveyor used for withdrawing coke from the wharf, all handling units of the plant are duplicated and of sufficient capacity to deal with the coke produced by the proposed final installation of eighty-eight ovens.

Carburetted Water Gas Plant

The carburetted water gas plant, now under construction, will serve the dual purpose of providing diluent gas to reduce the calorific value of the straight coal gas produced in the coke ovens and horizontal retorts to the standard calorific value of 500 B.Th.U. per cubic foot, and meeting seasonal fluctuations in demand or heavy peak loads without incurring the high cost of maintaining a large proportion of standby carbonising plant.

In order to secure the wide range of flexibility required, this plant has been designed to produce three types of gas: producer gas at 130 B.Th.U. per cubic foot, blue water gas at 290 B.Th.U. per cubic foot, and carburetted water gas at about 400 B.Th.U. per cubic foot or above. Carburetted water gas will be produced during periods of heavy demand, but for periods of moderate or low demand the manufacture of blue water gas will be sufficient to meet needs and will be more economical.

The plant will consist of four sets of back-run carburetted water gas generators, the site layout allowing for future extension to eight sets. Each set will be fully automatic and will comprise a generator with automatic fuel feed and ash removal, carburettor, superheater, waste heat boiler and wash box. The generators will

be equipped with annular jacket boilers, generating steam at a pressure of 50 lb per square inch for use in the water gas process or for saturating the blast when making producer gas. Steam at 160 lb per square inch to meet all power requirements of the plant will be produced in vertical multitubular fire-tube waste heat boilers.

An unusual feature of this plant will be the provision of alternative means of cooling the gas produced. Condensers are essential for the cooling of carburetted water gas, but producer gas is best cooled by the direct contact, unfilled scrubber tower. Accordingly, coolers of both types will be provided, together with a suitable arrangement of valves to permit a ready change-over from one system to the other to suit the type of gas being manufactured. A single-lift relief gasholder of 200,000 cubic feet capacity will be used to compensate for irregularities between the rates of production and demand.

The rated capacity of each of the sets on the three alternative phases of manufacture is: producer gas, 2·5 million cubic feet per day; blue water gas, 3·2 million cubic feet per day; and carburetted water gas, 3·5 million cubic feet per day.

Some 200 tons of coke per day will be needed to maintain all four sets of gas generators together on full load.

Power Station

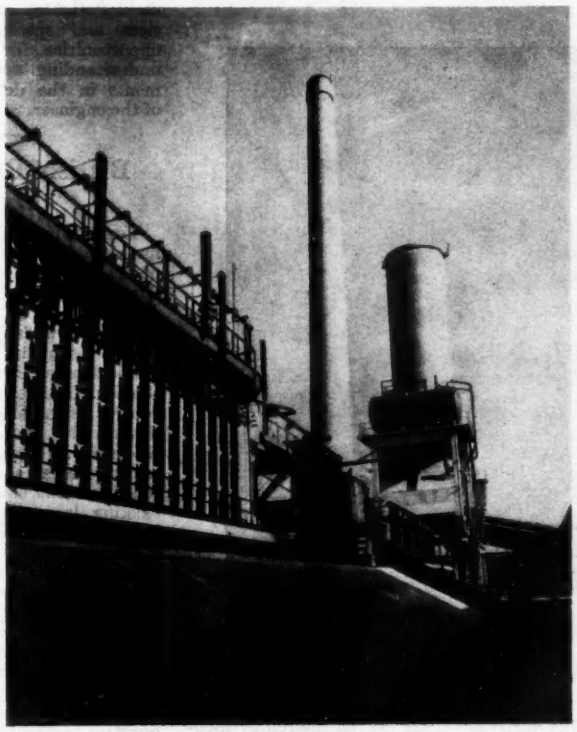
To supply power for the new plant two turbo-alternators, each of a rated output of 2000kW, have been installed on the first floor in a building of sufficient size to house two additional turbo-alternators in future extensions.

All steam and water services to the turbo-alternators are installed in the basement below the main hall of the building. The transformers and low-tension switchgear for plants adjacent to the power station are installed on the second floor. High-tension switchgear (which is remote controlled from a central control panel in the hall) is housed in a room comprising the third floor of the building, and as a precautionary measure provision has been made for flooding this room with CO_2 in the event of fire.

The two 2000kW turbo-alternators are arranged for operating in parallel, and each set is driven by a 3000 b.h.p. multi-stage, impulse geared, condensing type steam turbine, made by W. H. Allen, Son and Co., Ltd. The turbines run at 4500 r.p.m. and are operated by steam at 145 lb per square inch and 450 deg. Fah. Steam is supplied partly by waste heat boilers installed on the horizontal retort benches and partly from the annular jacket boilers of the producer gas units. The steam consumption of each turbine when on full load is slightly over 30,000 lb per hour.

The alternators supplied by Lancashire Dynamo and Crypto, Ltd., are of the revolving field type and are driven by the turbines through 4½ : 1 ratio double helical reduction gearing at 1000 r.p.m. Each of these units has a continuous maximum rating of 2500kVA (0·8 power factor) at 6·6kV and is mounted, together with the exciter and pilot exciter, on a common bed-plate bolted to the base under the reduction gearbox.

At five points in the works current is taken from a high-tension ring main to local sub-stations, where it is transformed down to a working pressure of 400V. Continuity of supply is ensured by the duplication of the generating equipment and by the adoption of the ring main system of distribution. Mercury arc rectifiers convert the alternating current to direct current for variable-speed motors, when required.



Quenching Station

Instrumentation as Applied to Diesel Engines

A paper entitled "Instrumentation as Applied to Diesel Engines" was read by R. J. B. Keig, M.A., before the Diesel Engine Users Association on November 16th and is summarised below.

Mr. Keig said that the rapid advance of diesel engine design was due largely to the research and development work carried out in laboratories, and this had led to a demand for specialised instruments, some of which he described to illustrate the advantages of electronic methods for measuring rapidly changing quantities. The properties of the thermionic valve had made possible the production of recording equipment which was free from inertia. The author traced the development of an instrument, which incorporated an electromagnetic unit connected into a bridge circuit fed with high-frequency alternating current, an amplifier and a cathode-ray oscillograph, which responded to frequencies down to zero. A valuable feature of the low-impedance unit, especially when used on fuel systems, was its immunity from damage by ingress of oil, but a disadvantage was the tendency for zero drift with change of temperature.

Equipment of this design, with a frequency limit of 1000 c/s, had been used to record the movement of a diesel engine crankshaft journal in its bearing, but for recording cylinder pressure diagrams, fuel line pressures and injector movements an instrument with a carrier frequency of 100,000 c/s was developed.

It had been found that suction, depression and ignition lag vary with the cetane number, and for determining the cetane number rating of diesel fuel the Standard-Sunbury indicator had been found convenient, as the rate of change diagram gave a clear indication of the start of combustion. Slight cycle-to-cycle variations in some engines caused instability of the oscilloscope screen image, but the use of the "Solatron" ignition delay meter had overcome this difficulty.

The paper stated that increase in operating speeds and reduction in weight had increased vibration problems. Inertia-free electronic circuits plus electrical filter circuits, which could analyse complex vibrations into component harmonics, had assisted the study of shaft torsional vibration and noise emissions. The Standard-Sunbury cathode-ray oscilloscope, in conjunction with a torsional vibration pick-up, was widely used.

In connection with the rate of wear of rubbing surfaces the "Talysurf" surface finish analyser was mentioned, in which a pen recorder produced a magnified profile diagram of the surface and an averaging meter gave an average roughness value. Plastic replicas of inaccessible surfaces can be jig mounted for analysis by the instrument.

Reference was made to the widespread use of electrical strain gauges, in which change in ohmic resistance was proportional to the strain in the electrical conductor, particularly at points where the bulk and weight of mechanical and mechanical-optical extensometers limited their application.

In the paper it was stated that knowledge of temperature distribution and heat flow in pistons, and also the arrangement of isothermal lines at points remote from the boundaries, was necessary for the production of improved designs. Fusible plugs have been used for recording piston temperatures, but a new apparatus, based upon the close analogy between the fundamental relationship for the steady flow of heat and for the steady flow of electricity, had been devised, in which a high impedance "null indicator" was essential and also the use of silver electrodes to avoid polarisation.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

GRAPHICAL SYMBOLS FOR GENERAL ENGINEERING, PART III: GRAPHICAL SYMBOLS FOR COMPRESSING PLANT

No. 1553, Part III: 1950. This part of the standard for graphical symbols for general engineering relates to the specialised field of compressing plant, including applications to air-operated switchgear, and covers compressors and auxiliary plant, such as coolers, dryers and receivers, with examples of diagram showing the use of the symbols. Price 2s., post free.

BUTTRESS SCREW THREADS

No. 1657 : 1950. This standard provides for two forms of buttress screw threads, designated, respectively, "Standard" and "Special" forms. The "Standard" form of thread has a pressure flank angle of 7 degrees, with an included angle between the pressure and trailing flanks of 52 degrees. In selecting the form of the standard thread, manufacture by the thread milling or grinding processes has been taken into consideration.

The "Special" form of thread has the pressure flank normal to the axis of the screw with an included angle between the pressure and trailing flanks of 52 degrees. This special form is unsuitable for manufacture by thread milling or grinding but may be required to meet certain special requirements, as for example, applications in high pressure steam work involving differential expansions of the mating threads in which the provision of a 7 degree pressure flank might give rise to high bursting stresses.

As the use of buttress threads is confined mainly to specially designed components, no attempt has been made in the standard to introduce a rigid pitch/diameter relationship, but the standard does include preferred series for both diameters and pitches. Tables of tolerances and allowances are provided for three classes of fit, namely, close, medium and free. A recommended system of gauging is included in the specification, with notes on the appropriate types and design sizes of the gauges. An explanation is also given of the method of measurement of the effective diameter of buttress threads, together with tables of dimensions for the best sizes of thread-measuring cylinders. Price 3s., post free.

Extensions at the College of Technology, Manchester

THE completion of the first stage in a comprehensive programme of extension and improvement at the Manchester College of Technology was marked, on December 7th, by the formal opening of large new laboratories for the Department of Mechanical Engineering. This college, which had its origin in the Manchester Mechanics Institution, founded in 1824, was transferred—as the Manchester Municipal Technical College—to its site in Sackville Street, in 1902, when some of its activities were amalgamated with those of the new Victoria University of Manchester. It is now the leading technical college in a wide regional scheme dealing with advanced subjects for the Higher National Certificate, special courses on the most recent industrial developments, and refresher courses for instructors, research workers in industry, &c. The college also incorporates the Faculty of Technology in the University for students working for Bachelor's, Master's and Doctor's degrees. A considerable amount of fundamental research into industrial problems is carried out and at present some twenty major projects are in hand. The problems now being investigated cover fatigue, lubricants, special instruments for use in relation to heat problems, heat transfer at high and low temperatures, machine tool design and vibration, fundamentals of cutting tools, vibration in welded structures, hydraulic power transmission, the behaviour of materials on the fringe of the elastic range, &c.

MACHINE TOOL LABORATORY

Work on the construction of the main new laboratory building was started shortly before the war. The original plan was to provide facilities for the study of heat engines, but in the light of more recent requirements and the trend of industry it was decided to change the plans and adapt the building to accommodate an extensive machine tool department and the newly-formed metrology department.

In the centre of the new machine tool laboratory, a photograph of which is reproduced on this page, is a large well, which was sunk to accommodate the condensing equipment of the steam plant, for which the building was originally intended. When the revised lay-out of the building was being considered it was decided that, rather than provide a small additional floor area by filling in or covering the well, a far greater floor area could be obtained by using the well and building rooms beneath the main floor on the two sides. This form of construction has provided a machine laboratory, and six metrology laboratories.

Three sides of the machine laboratory round the central well have been equipped with machine tools and the fourth side with light welding equipment. The equipment includes a comprehensive range of recent designs of machine tools, together with representative examples of high precision tool room plant as used in modern works. Few machine tool laboratories are better equipped for the study of metal machining processes and of the design and functioning of modern machine tools.

The various sections of the metrology laboratory contain a very complete range of precision instruments for the measurement of size, form and surface quality gauging; measuring apparatus for gears, splines, &c.; large-scale metrology apparatus, and optical projecting equipment. In the lay-out and selection of equipment for the metrology laboratory the College has had the guidance and assistance of the National Physical Laboratory and works closely in contact with it on the development both of teaching and research.

The inauguration of this well-equipped and modern metrology laboratory will provide valuable facilities for post graduate study and make possible the introduction of refresher courses in precision measurement, which now is important in many branches of industry. Hitherto facilities for people already in industry to study the fundamental principles underlying precision measurement and to obtain practice on a wide range of first-class equipment have been very limited. In the establishment of this department the college has provided the means of filling a noticeable gap in engineering education and facilities, of which industry should take full advantage in its own interests. The nature and duration of the classes can be moulded to suit the needs of industry. Such courses can be for as long as a year or as little as a single week. Evening classes in metrology are also conducted for those working in the Manchester area.

During recent years practically the whole of the equipment of the Department of Mechanical Engineering at Manchester has been replaced by plant of modern design and many of the laboratories have been extended and rearranged. In order to undertake specialised studies, several new laboratories have been opened and, with the assistance of the branches of industry particularly concerned, have been fully equipped. Now, with the opening of the new laboratories, bringing the total to twenty-three, additional space has become available and further rearrangement of laboratories and equipment, which is proceeding, will increase both the teaching and research facilities.

No laboratories are set aside exclusively for research and teaching and research proceed side-by-side in all sections. By this practice students in the normal course of their training are familiarised with research procedure, the development of special apparatus, and the care and attention to detail which are required when planning and carrying out experimental research. The contact between the many aspects of teaching at the college—for undergraduates and post-graduates, apprentices and specialists alike—provides unique opportunities for mutual development and understanding and for well planned experiments in the development of the education of the engineer.

British Railways Research Organisation

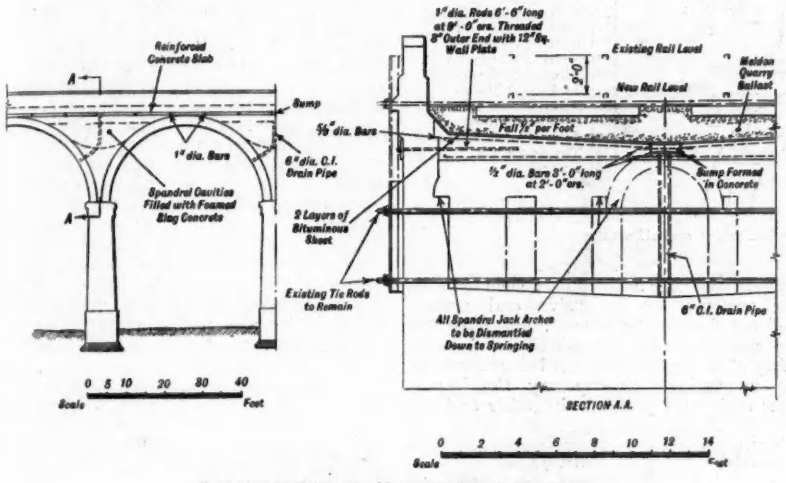
THE Railway Executive announces that it has decided to integrate the research facilities of the different regions into a single research department, which will come into operation on January 1, 1951. This step has been taken in accordance with the recommendation of a committee set up by the British Transport Commission under the chairmanship of Sir William Stanier. The new department will be under the control of a director of research responsible directly to the chairman of the Railway Executive. It will have seven divisions, each under the immediate control of a superintendent. The chemistry division will embrace existing laboratories in each region. These laboratories will continue to be concerned with work arising in the regions, but major researches of a chemical nature will be allocated to whichever laboratory is most suitable. The engineering, metallurgy, protective coatings, physics and textiles divisions will be situated at Derby, where the necessary laboratory facilities and staff already exist; there will also be a subsidiary engineering laboratory at Ashford. An operational research division will have its headquarters in London. The research department will establish a central library and information centre, and a monthly bulletin will be issued to keep officers informed of the contents of the library, and to draw their attention to research reports, issued by other organisations. The services of this department will be available to all other departments throughout British Railways. Mr. T. M. Herbert, formerly Research Manager, L.M.S., has been appointed director of research, and Mr. E. Morgan assistant director; the superintendents of the various divisions of the new department will be Mr. T. Baldwin (engineering), Mr. T. H. Turner (metallurgy), Mr. T. A. Eames (physics), Mr. F. Fancutt (chemistry), Mr. C. G. Winson (textiles), and Mr. M. G. Bennett (operational research).

INFLUENCE OF RESIDUAL STRESSES ON THE FATIGUE STRENGTH OF STRUCTURES.—A report, by Professor M. Ros, of Zurich, on "Experiments to Determine the Influence of Residual Stresses on the Fatigue Strength of Structures," was published in the October issue of *Welding Research*, the journal of the British Welding Research Association. 29, Park Crescent, London, W.1. It deals with a series of fatigue tests, in which residual stresses were introduced by forcing a plug into a round hole made in a flat plate by pinning together two pieces of plate whilst under stress, and by welding plugs into holes trepanned in flat plates. The conclusions of the report are that the effect of residual stresses on fatigue strength is not likely to exceed 8 per cent.

The Repair of Hurstbourne Viaduct

THE repair and maintenance of old structures presents a whole range of engineering problems, the solution of some of them involving great ingenuity and skill. A recent example of an interesting method of repair is that of the work now proceeding at Hurstbourne Viaduct, on the Southern Region of British Railways. In this case the task is complicated by the necessity of maintaining a single line track over the viaduct, which carries the main Southern Region line to the West of England, throughout the course of the work. Careful timing has also been necessary with the limited possessions allowed on the single line for bringing constructional materials to the site.

Hurstbourne Viaduct is situated between Hurstbourne and Andover, across the Bourne Valley, and was opened in 1854. It consists of nine brick arch semi-circular spans, each of 46ft. The maximum height of rail level above the ground is about 65ft: the ballasted tracks over the viaduct are supported on five longitudinal jack arches springing from spandrel walls built up from the arch spans and piers, and running along the entire length of the structure.


Reinforced Concrete Slab
A
Sump
1" dia. Bars
6" dia. C.I. Drain Pipe
Spandrel Cavities Filled with Foamed Slag Concrete
2 Layers of Bituminous Sheet
Existing Tie Rods to Remain
0 5 10 20 30 40
Scale Feet
1" dia. Rods 6'-0" long at 9'-0" crs. Threaded 8" Outer End with 12" Sq. Wall Plate
Existing Rail Level
New Rail Level
Meldon Quarry Ballast
5/8" dia. Bars
Fall 1/2" per Foot
1/2" dia. Bars 3'-0" long at 2'-0" crs.
Sump Formed in Concrete
All Spandrel Jack Arches to be Dismantled Down to Springing
6" C.I. Drain Pipe
SECTION A-A.
0 2 4 6 8 10 12 14
Scale Feet

ARRANGEMENT OF HURSTBOURNE VIADUCT

The condition of the spandrel walls and jack arches, which are of relatively light construction, has gradually deteriorated since the building of the viaduct nearly a century ago and fairly extensive repairs have become necessary. A simple solution would have been to replace the walls and jack arches with reinforced or mass concrete, but a series of tests have indicated that additional weight at a high level would be undesirable and might tend to cause side sway of the viaduct as a whole. It was therefore decided that the required strengthening should take the form of introducing solid concrete filling to the spandrel cavities of each arch, and the laying of a continuous 9in thick, reinforced concrete slab throughout the length of the viaduct. Finally, the track is to be lowered about 2ft to prevent an increase in the dead load as a result of the works. This last measure involves the removal of a layer of chalk filling, which was placed on the viaduct as a maintenance measure many years ago, presumably to spread loads more evenly over the jack arches.

The accompanying illustration shows in section the weak spandrel arches (five in number) to be demolished after the solid filling of the cavities underneath has been completed. The new reinforced concrete slab, laid to falls to facilitate drainage, and the lowering of the rails over the viaduct is also shown. This latter work, of course, involves regrading the approaches to the viaduct.

To carry out the work with reasonable expedition it was necessary to reduce the double line railway to a single line for a distance of about half-a-mile to provide working space on the viaduct and to regrade the approaches. The lay-out and signalling arrangements for the single line working provide for non-token operation with the signalmen at Hurstbourne having control of both ends of the line. At the same time a speed restriction of 15 m.p.h. is imposed.

To maintain the stability of the structure while half of its width only is subject to live loading, it was necessary to fill the spandrel cavities without removing any appreciable quantity of the existing fill over the viaduct. Timbered shafts 15ft by 5ft in plan were therefore sunk over each pier and the spandrel arches broken through. Concrete was then poured from a mixer at the top and by this means three arches, each 28ft long (one under the 6ft and two smaller ones under the up-track and cess) were filled solid.

This work was followed by the construction of a bag wall (dry mixed sand and cement) in a trench alongside the sleeper ends of the single line, to retain the filling under the single line, while the remainder of the fill on the viaduct was removed. As the excavation proceeded, following the bag wall construction, the brick deck over the spandrel arches was exposed and all the brickwork (most of which suffered from perished mortaring) in the arch rings and backing, was pulled up and removed and the resulting void filled with concrete, which was extended to the crown of the main arches.

The concrete used for both these filling operations was a light-weight type made with foamed slag aggregates. The mix used consisted of 112lb of cement to 4 cubic feet of coarse aggregate (¼in to ½in) and 4 cubic feet of fines (up to ¼in), the resulting concrete being nearly 40 per cent lighter than a normal mix.

On top of the light-weight concrete filling, construction of the r.c. slab (in normal concrete) has commenced. This will later be waterproofed by a liquid bituminous compound and layers of roofing felt, which in turn will be overlaid with protective concrete. On completion of the slab construction, the up-track will be relaid and the single line rerouted over the new slab to permit similar treatment of the second half of the viaduct.

Owing to lack of space, the supply of constructional material to the viaduct site is arranged in small quantities by a daily train. A total of 800 cubic yards of light-weight concrete will be required with 360 cubic yards of reinforced concrete in the slab. Some 3000 cubic yards of excavation will be entailed in removing all the fill from the viaduct and regrading the approaches.

The Control of Hydro-Electric Plant*

By A. C. H. FROST, B.Sc.(Eng.), A.M.I.E.E., and W. BRITTLEBANK, B.Sc., A.M.I.E.E.†

Elements to be Controlled

ALTHOUGH machines differ widely in physical appearance, there are comparatively few basic types of turbine, and the main elements described below are common to all. The head of water available determines whether impulse or reaction turbines are to be used, and the output and speed of the plant governs the choice between horizontal and vertical shaft arrangements.[1, 2, 3, 4]

Fig. 1 shows the main elements of a vertical Francis turbine installation—the most common form found in practice.

Main Water Supply to Turbine Casing.—Some means for cutting off the water supply to the turbine casings are required, to avoid wasteful leakage when the unit is shut down and to permit access for maintenance. When the dam and the turbine house are integral, simple stoplogs at the intakes and inlet valves adjacent to the turbines are adequate for this purpose, although the inlet valve may be omitted at low-head stations. When a tunnel and a pipe-line connect the reservoir to the turbines, the intake has a motor or hand-lifted, gravity-lowered gate, preferably with an automatic release operated by an excess flow paddle if a burst occurs. A portal butterfly valve is commonly provided at the junction of the tunnel and the pipe-line if the latter is long, and either this valve or the intake gate should be arranged for remote closure by hand in an emergency. Nowadays, both pipe-lines and portal valves are often omitted for the sake of steel economy and improved appearance by constructing pressure tunnels right down to the station.

Main inlet valves are frequently of the butterfly design, but cylindrical, spherical and conical valves are also used.[2] All types of valve incorporate arrangements for the slow filling of turbine casings by "crack openings" or special bypasses. Whereas bypass valves are either hand-, motor- or water-servo-motor controlled, main valves are nearly always operated by water servo-motors. The opening motion of the main valve is preferably arranged to occur automatically when downstream pressure is established. Open flumes can sometimes be employed in place of expensive tunnels, though operating conditions become involved and fine remote control of the intake gates is essential. The main inlet valve and the intake gate are the final safeguards against turbine or pipe-line disasters, respectively, and the shut-down control must be absolutely reliable.

Runner Water Admission and Relief.—The admission of water to the runners in accordance with the load demand is controlled by needle-adjusted nozzles in impulse turbines and by venetian blind type guide vanes in reaction turbines, both forms of control employing oil servo-mechanisms. Rapid reductions of flow may cause disastrous water-hammer fractures; hence, slow-closing features are always introduced. To this end, in impulse turbines, deflector plates take the work off the runner instantaneously, the jet being cut off gradually afterwards. In reaction turbines, relief valves with rapid-opening/slow-closing characteristics operate hydraulically as the guide vanes close. At low-head stations with short intake passages, however, the relief valve can often be omitted. In Kaplan machines the runner blades are of variable pitch and are adjusted simultaneously with the guide vanes by means of a further oil servo-motor within the runner hub.[1]

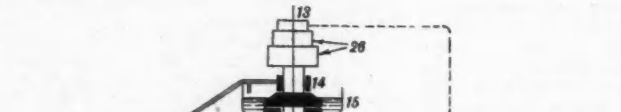
Governor Servo-System.—To meet the intermittent oil demands of the servo motors each turbine has its own air/oil reservoir fed by a positive type oil pump with an automatic unloader valve. The initial air charge is provided by a separate compressor, but, as the total oil volume is constant, subsequent air

* Abstract. Paper, Institution of Electrical Engineers, December 7th, 1950.

† Mers and McLellan.

leakage can be compensated for by an automatic air pump controlled by the sump level. The reservoir, which is normally half full, contains enough energy stored in the compressed air to ensure full closure of the nozzles or guide vanes in an emergency.

The servo-motor oil admission is controlled by the governor, employing up to three oil relays in series. The main servo-motor operates (through direct mechanical linkage) the deflector plates and pilot valves of the nozzle servo-motors of impulse turbines, or the guide vanes and pilot valves of the relief valve servo-motors of reaction turbines. The governor oil systems in one station are often interconnected



(1) Filling by-pass
(2) Main inlet valve
(3) Spiral casing
(4) Fixed guides
(5) Guide vanes (pivoted)
(6) Runner
(7) Relief valve
(8) Oil servo-motor
(9) Governor
(10) Air/oil reservoir
(11) Governor pump
(12) Synchronous motor
(13) Permanent magnet generator
(14) Upper guide bearing
(15) Thrust bearing
(16) Middle guide bearing
(17) Lower guide bearing
(18) Bearing oil cooler
(19) Bearing oil pumps
(20) Alternator air coolers
(21) Jacks and brakes
(22) Alternator stator
(23) Alternator rotor
(24) Alternator heaters
(25) Thrust girders
(26) Exciters

FIG. 1—*The Elements of a Typical Francis Turbine and Alternator*

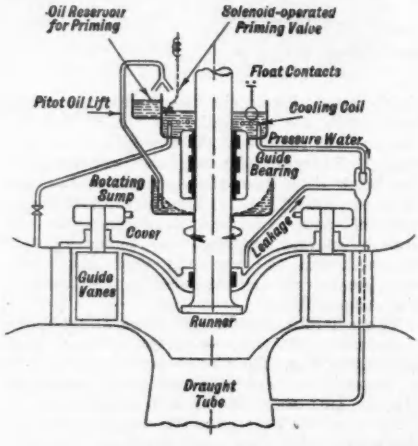
and pump sizes are so chosen that outage of one pump is permissible; one common standby pump of similar size is often provided. By careful mechanical design of the equipment oil pressure failure results in only about 50 per cent of the full water admission to either impulse or reaction turbines when hydraulic equilibrium is established. Large machines usually have double-acting servo-motors, but small machines can be arranged for emergency shutting down by employing single-acting servo-motors with spiral return springs.

Frequent load fluctuations entail continuous pumping, which may overheat the oil, and governor instability sometimes results. Water cooling coils are therefore often provided in the oil sump.

Governor Drive and Speed and Load Setting.—The governor flyballs may be coupled to the main shaft directly or by gearing, belting or electric drive. Vertical shaft machine governors can rarely be coupled directly, for reasons of accessibility. Gear drives are often troublesome, and belts are both vulnerable and unsightly, so that modern practice favours electric drive,[4] in which both the generator and the flyball motor are synchronous machines with permanent magnet rotors. Electric drive is highly reliable and no protective devices are fitted. Formerly, flyball and oil pump drives were integral, but when the pump unloader operated, the flyballs were disturbed; a separate electric drive for the oil pump is now universal. Speedermotors of the split series type are normally provided for speed and loading control. Turbines capable of full output at minimum head can often seriously overload their generators at maximum head, so that governors are usually fitted with load limiters, which are sometimes remotely controlled. The load limiter adjustment usually extends down to zero and thus affords a means for remote stopping and starting at a safe and controlled rate. Another method employed to give slow-starting facilities is that in which a restricting orifice is introduced in the oil system connecting successive oil relays in the governor mechanism.

Lubrication Systems.—Horizontal sets are intrinsically simple to lubricate, the journal and thrust bearings commonly having independent oil baths with internal water cooling coils. Large machines may need external coolers with oil circulating pumps.

Vertical sets require a heavy thrust bearing and up to four guide bearings. Oil heating is naturally more severe in the thrust bearing, which, together with one guide bearing, generally runs fully immersed. The other guide bearings are of the top and bottom sump type and can either be self-contained or combined with the thrust bearing oil system. The arrangement depends also on the cooling method adopted. In earlier machines each bearing incorporated water cooling coils, but separate coolers with small oil circulating pumps have become fashionable; such external cooler systems are expensive and greatly complicate foundation lay-out, but have the advantage of greater accessibility and easier priming of the guide bearings before starting. Some interesting contemporary Continental designs omit such priming altogether and use



The oil reservoir is replenished by the Pitot pump. The solenoid-operated priming valve is opened when the main valve is fully opened and closed when the running speed reaches 80 per cent of the maximum. The float contacts prove the presence of oil before running-up is commenced.

FIG. 2—*Suggested Lubrication and Leakage Disposal Scheme for a Vertical Reaction Turbine*

built-in cooling for all bearings. Independent lubrication is desirable for turbine guide bearings which risk contamination by water leaking from the cover, and separate pumps are often employed for this purpose. Fig. 2 shows a possible method of priming such bearings before starting without using pumps, and of combining oil cooling with leakage water ejection.

An oil purifier of the centrifuge type is provided—in mobile form when access permits—to avoid expensive fixed piping. Servo mechanisms and nozzle or guide vane motions are greased by hand.

Generator Cooling Systems.—Generator cooling involves air circulation by rotor fans. Open ventilation is usual for generators up to, say, 5000kW capacity in Britain, but larger machines justify closed systems with water cooling for increased cleanliness and minimum fire risk. Up to 25 per cent of the circulating air is often bled from closed systems, through manually operated louvres, for station warming, the make-up air entering through dust filters. If internal fire protection using carbon dioxide is provided, automatic closing of the louvres is arranged mechanically. Open ventilation systems are sometimes arranged so that they may discharge to the outside of the building in summer and to the inside of it in winter. The water supply for both air and oil coolers can readily be drawn from the turbine casing, through reducing valves and strainers, so that it flows automatically when the main inlet valve opens. Where the water head exceeds 300ft, however, it is more economical to pump from the tail-race; each turbine may then have its own pump, generally with one standby which is common to all.

Braking and Jacking Systems.—Braking assists big machines to minimise bearing wear by restricting protracted slow running before stopping. Impulse turbines have separate reverse-acting jets controlled by independent oil servo-motors. When remotely controlled, these jets must be cut off when the machine has stopped, to prevent counter rotation occurring. Horizontal reaction machines may employ special brake drums. The heavier vertical machines require more powerful brakes in the form of oil jacks under the generator rotor, which press friction pads against a special rim, the pressure being applied through an air/oil reservoir. The same jacks are employed for lifting the vertical shaft (the pressure being applied by a high-pressure oil pump and suitable valves), for withdrawing the thrust pads and to assist in other dismantling operations. In addition, jacks are sometimes used to lift the shaft before starting, in order to flood the thrust bearing pads.

Miscellaneous Equipment.—Generators for use in cold climates frequently have internal heaters (6kW to 15kW) for preventing moisture condensation after shutting down and for avoiding deterioration of the insulation and the iron laminations.

Some leakage through the cover gland generally occurs with vertical turbines (especially at low-head stations without inlet valves), and this requires ejectors or level-controlled motor-driven pumps. Gravity drainage of the turbine cover, via hollow fixed guide vanes to the turbine draught tube or to the station sump, is sometimes possible for vertical reaction turbines. (See also Fig. 2.)

Horizontal set stations can generally drain leakage water to the tail-race, but the depth of the spiral casing of vertical set stations necessitates sumps with level-controlled drainage pumps. Embedded pipework systems are often employed for vertical sets to connect draught tubes and relief valves to a common pump, so that all water may be removed and access for maintenance permitted after the insertion of tail-race stoplogs.

A water supply for transformer cooling is frequently required, but the cost of a transformer with water pumps or pipe-lines pressure reducing valves, pipework and cooler maintenance is rarely less than that of a transformer with air blast cooling, besides its introduction of freezing troubles in outdoor locations.

Combined systems are wasteful of auxiliary power or pipe-line water, since total head conditions differ widely in the transformer, generator and bearing cooler branches.

Dam equipment varies greatly, but often entails motor-operated flood and draw-off gates, and level-controlled motor-operated sluices when fish passes are required.

Pumped Storage Schemes.—Some sites permit the economic use of large pumps to replenish reservoirs for later peak generation.[3] Separate motor drive is simple and flexible, but is costly, and pumps are often coupled to horizontal

water turbine-driven generators. The set is synchronised as a generator, then the turbine is dewatered and the pump delivery is opened, so that the generator becomes a synchronous motor. To prime the pump the shaft level must approximate to that of the lowest tail water; hence, the idle runner casing must be cleared by compressed air.

[Here the author discussed the alternative arrangements for power supplies to auxiliaries, and outlined the advantages of the unit system.]

Methods of Controlling Water Turbines

Manual (Mechanical) Control. — Manual (mechanical) control, though formerly universal and cheapest, is less common nowadays, because of the desirability of easy conversion to remote control. Bypass sluice valves of up to 8in bore can comfortably be operated manually, and when the turbine casing is full the main inlet valve can be operated either by a hand pilot valve or by the servo action of the pressure water from the downstream side. Hand gear for the positive control of the admission of water to the runner is normally provided on the turbine servo-motor, allowing the machine to be brought up to speed under hand control, after which the governor can be clutched in. Synchronising and load control are normally performed by the driver in small isolated stations using hand controls, but these controls are brought to the switchboard in larger stations. Gauges are often distributed around small turbines, but are collected on a gauge board for larger machines.

Manual (Push-Button) Control.—It is a relatively simple—though expensive—matter to fit solenoids to the servo motor pilot valves and to motorise the sluice valves so as to permit centralised push-button control. This step also provides the elements essential for automatic control if subsequently contemplated. The location of the control point is a matter of opinion, but, since it is desirable to provide the operator with lamp indications of plant conditions not immediately visible, as well as the usual gauges, it is preferable to develop the gauge board into a complete turbine control panel. Power stations warranting push-button control usually have the switchboard in a separate operating room, from which synchronising and loading are performed by remote electrical control.

Manual (Cottage-Attended) Control.—Stations on isolated systems can safely be left for long periods under the control of the turbine governors and automatic voltage regulators, thereby reducing expensive three-shift staffing to one attendant and a relief man. It is essential, however, to provide comprehensive alarms of plant irregularities, with a warning bell at the attendant's cottage. For stations with more than one machine, it is desirable to arrange for load-sensitive devices to sound the alarm when the load reaches the capacity of the running plant.

Semi- and Fully-Automatic Control

A variety of methods can be employed for starting and stopping turbines, methods which apply equally to both semi-automatic and fully automatic stations. These methods range from the "sequential system"—in which the various mechanisms and auxiliaries are put into operation one after the other as each previous operation is proved complete[5, 6, 8]—to a scheme employing a moving controller which sets independent operations in motion as it passes through successive positions. The most desirable scheme lies between these two extremes. This method, known as the "sequential/parallel" system, is illustrated in Fig. 3; it has the advantage of combining simplicity of electrical equipment and circuits with minimum starting time.

Starting Sequence.—The starting impulse energises a master control relay, which remains latched-in whilst the machine is starting and running. This relay starts the standby lubricating and governor oil pumps and at the same time initiates the opening of the main inlet valve and starts a timing relay for an excessive starting time alarm. Thus, the slowest operations involved in starting the machine are initiated to run in parallel in this first stage, thereby minimising the total starting time. Pressure switches and flow relays on the oil systems, and limit switches on the main inlet valve, prove that the first stage is complete and initiate the guide vanes (or nozzles) opening circuit for the second stage. If the simplified unit scheme described above is in use, the essential auxiliaries commence running as the machine gathers speed, and, by virtue of pressure switches on their delivery lines, automatically shut down the standby pumps.

The final stage involves the proof of delivery from the normal auxiliaries, coupled with operation of a voltage relay energised by the pilot exciter or the permanent magnet generator

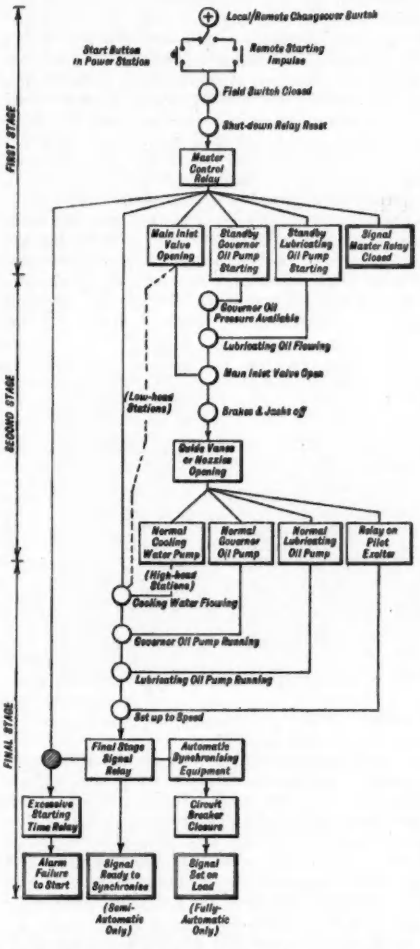


Fig. 3—*Sequential/Parallel Scheme for Automatic Starting of Turbines*

when the machine is up to speed, which simultaneously energises a final stage signal relay and de-energises the excessive starting time relay. Failure in any part of the sequence will result in the excessive starting time relay completing its operation, thereby transmitting a signal "failure to start" and de-energising the master control relay, thus returning the plant to its shut-down position. The final stage signal relay brings in the automatic synchronising equipment—in fully automatic stations—or transmits a signal "ready to synchronise" in semi-automatic ones. Loading and synchronising of semi-automatic machines is carried out in the conventional manner by remote electrical control.

In both systems it is desirable that the field switch be left permanently closed, tripping only when the generator protection operates, after which it must be reclosed by hand.

Stopping Sequence.—On receipt of a "shut down" impulse the master control relay is tripped, thus energising the closing circuits for guide vanes (or nozzles) and main inlet valve. As the generator voltage falls the normal auxiliary pumps stop and the standby pumps commence working automatically. Brakes are applied to the main shaft when the speed falls below 50 per cent of the normal, generally by a tachometer contact. A time-delayed stopping relay releases the brakes and shuts down the standby pumps after the turbine has come to rest.

In some systems the generator circuit breaker is tripped by means of a no-load contact on the guide vanes motion. A safer arrangement is to reduce the load and trip the circuit breaker prior to initiating the stopping sequence, using suitable interlocks in the master control relay trip circuit.

Control Change-Over Facilities.—With any system of automatic control it is very desirable to provide automatic starting and stopping facilities at the machine itself. The local automatic control facilities may be employed for testing purposes and may also enable semi-skilled personnel to start or stop a machine in the event of remote control failure. Furthermore, manual push-button control should be provided for use if the automatic gear itself fails and for maintenance, when individual functions may require to be tested independently. "Local auto/remote auto" and "auto/manual" change-over switches are generally provided for these purposes, and it is important to arrange that the "auto/manual" switch should be capable of safe operation during any condition of starting or running, a requirement involving much ingenuity in the circuit design.

Synchronising Systems for Fully Automatic Control

To minimise both system and winding disturbances set up when connecting a generator in parallel with a network it is essential to prove that the frequencies are the same and that the voltages are in phase and approximately equal before making the connection.

One method of synchronising which has been employed in the past is that of closing the generator circuit breaker at approximately 95 per cent speed and then applying the field.[9] Such generators are generally equipped with an amortisseur to develop maximum synchronising torque,[5] but such a system is not to be recommended for machines over 5000kW rating, in view of the voltage disturbance which it may cause.

A scheme in use on the Continent is that of causing the governor to hunt about normal speed until both voltage and phase difference conditions are satisfied by chance during one oscillation through synchronous speed, and then closing the circuit breaker. This, however, is also likely to cause some system disturbance.

A number of standard types of automatic synchronising equipment are now being manufactured, each consisting of the following main components:—

Voltage Matching Relay.—This generally takes the form of a double-coil voltage relay with each of its coils connected to a different supply. With the relay in its neutral position a contact is made in the circuit breaker closing circuit. Any unbalance causes the closing of contacts which operate the appropriate excitation controls of the machine which is about to be connected.

Speed Matching Relay.—One synchronous motor is connected to each source of supply, and together they operate a differential gear which is friction coupled to a contact arm. At either end of its travel contacts are arranged to operate on the governor speedermotor. An alternative arrangement utilises a double-coil relay so connected to the voltage sources that the difference in frequency is an inverse measure of the time interval between the operations of each element. Switch closing is then only possible if a series circuit is maintained for a preset minimum period.

Phase Comparison Relay.—This relay ensures that the two supplies are in phase before completing the circuit breaker closing circuit.

Electrical and Mechanical Protection

The electrical protection of water turbine driven generators follows conventional steam generation practice, with the addition of overvoltage protection in view of higher runaway

speeds. The authors favour an overall balanced system, backed up by over-current, over-voltage and—when a step-up transformer is included—transformer oil surge and transformer winding temperature trips.

Mechanical protection necessarily varies slightly with turbine design, but the common items are outlined below. Unlike the practice current in thermal stations (with certain exceptions), the mechanical and electrical sides of water-driven machines usually inter-trip. The most serious hazards for all water turbines are overspeeding, overheating of the bearings and failure of the governor oil supply, all of which should cause the machines to shut down immediately. Other conditions may demand prompt, though not desperate, action, and should be dealt with on an alarm basis to avoid the shock administered to the system by the sudden disconnection of the power.

It is, however, in the treatment of the emergency shutting down of the turbines that most divergencies arise. Earlier designs simply closed the main inlet valve direct from the over-speed trip, leaving the opening of the circuit breaker to be performed manually—unless an electrical fault occurred simultaneously. It later became fashionable to elaborate the protection and to distinguish between those faults requiring immediate outage and those which permitted off-loading at a normal rate, the circuit breaker then being tripped as the servo-motor passed through the no-load position.[10] The resulting duplication of shut-down relays is unjustified by experience, and for safety and simplicity all main protective devices should operate one hand reset relay; separate contacts of this relay trip the main switch, open the field switch, close the main inlet valve, close the guide vanes or nozzles and apply the brakes; in automatic schemes the shut-down relay also restores the master control relay. These circuits should override all hand and automatic controls. The shut-down relay should be located on the turbine control panel in a readily visible position. Hand emergency trip facilities operating the shut-down relay should be provided on the turbine panel and on the local switchboard, but not at a remote control point, where insufficient knowledge is available to justify such drastic action.

Fully automatic stations may include stator air excessive temperature trips with the automatic tripping devices. Semi- and fully-automatic stations are generally provided with excessive starting time relays which trip only the master control relay, as described above.

Turbine Panel Lay-Out.—The use of the turbine gauge board as the control point for manual (push-button) turbine controls is becoming widely adopted in Britain, and the lay-out of gauges and control switches in some logical sequence is becoming increasingly desirable. The control switches, with their associated indicating lamps immedately above them, should be mounted at a convenient level on the panel and should read from left to right in the order of starting the plant; the gauges should be so placed that they are directly above the controls which affect them. The turbine panel is also the correct position for mounting alarm indicators, the turbine shut-down relay, the running hour meter and the machine rating plate. In automatic stations the turbine panel should also carry the control change-over switches and the "local automatic" start and stop buttons.

Power Station Operation

As with thermal stations, the main switchboard at a hydro-electric station provides the means for the supervision of outgoing circuits and for generator synchronising, loading and excitation control. Both forms of station have individual machine starting and stopping controls and equipment for the production and regulation of the working fluid. The obviously simpler processes of hydro-electric stations, however, require fewer mechanical than electrical staff, unlike thermal stations, where mechanical personnel preponderate. It is therefore possible—and, in several countries, fashionable—to combine the mechanical and electrical controls at one point, either in the conventional operating room or at the generator floor level and to employ only one set of operators on each shift. In Britain, however, attended stations tend to preserve the turbine driver category distinct from that of the switchboard attendant.

Whereas the switchboard always provides activity for its attendants, low load factor stations mean irksome idle periods for the turbine staff. High load factor stations (which are rarer) may justify full-time mechanical attendance to detect incipient troubles during long runs.

Electrical Operation.—The significant advantage of hydro-electric over steam machine control lies in its more rapid starting and loading; machines can often be brought safely from standstill to full load in less than five minutes.

Synchronising, however, provides the widest variations of treatment. Multi-pole machines require less critical synchronising, and, indeed, many applications abroad merely close the field switch after the main circuit breaker. No-load control is sometimes unsteady, however, especially with impulse turbines, and normal synchronising is recommended. Some of the newest Continental stations employ automatic synchronisers, even at attended stations, presumably fearing costly damage from human errors; this tendency is to be deprecated unless very rapid starting is the prime consideration, as operators should be kept in practice for emergency manual synchronising, and can be safeguarded, if desired, by inexpensive check synchronising relays. In fact, since no automatic equipment can anticipate reactions, proper hand control is probably gentler than automatic control.

Mechanical Operation.—Manual (push-button) control is often transferred from the turbine panel to the switchboard in mid-European stations, with pictorial presentation of the hydraulic conditions, but this elaboration is unnecessary, since, by semi-automatic control gear, safe and rapid operation is attainable and the switchboard staff do not need the intermediate indications.

Permanent water flow recording equipment is commonly provided for each turbine, simplifying routine checking of the turbine efficiency. Occasional check readings of temperature and oil pressure will reveal bearing wear, but hourly logging is rarely necessary. The chief occupations for mechanical staff are therefore periodic hand lubrication of the link mechanisms, clearing of water and oil strainers and checking against leakage water accumulations. All these duties can comfortably be left to a daily staff, and if dangerous flooding is possible sump levels can readily be fitted with alarms.

Group Control

The establishment of group control centres is a comparatively new conception. Where topography favours the development of a river system in several steps, as among the gentle slopes of our national uplands, the resulting chain of power stations form an interdependent group for storage and generation purposes. The family usually accumulates gradually—possibly commencing with some seasoned adults—and may adopt some isolated orphans, but the group control centre may be defined as consisting of the administrative, operational and maintenance functions of a single comprehensive "power station" whose components stretch throughout the developed river system. The group output is often collected at one major high-voltage substation, whence it passes *en bloc* to the primary transmission system, and operation of this substation forms an integral part of the group control duties.

For routine operation, as Table I demonstrates, it is more economical to use remote control by one set of shift staff at the group control centre than to staff individual stations. Nevertheless, group control functions can as readily be performed using some remote-controlled and some manual-controlled stations, if specially desired.

The nature of group control load dispatching duties depends upon whether the group comprises a self-contained generation/consumption system or if—as is more usual—it forms part of some major system, when the load demands will emanate from an outside central control room. In either case, however, the group control centre has to determine the allocation of load between its members, to achieve the requisite demand at the maximum generation and transmission efficiencies.

Electrical Information Required.—The group centre requires an indication of each machine load from which to derive automatically or statistically the total load on each power station and hence the total load on the group. When the group forms part of a major system in which reactive currents have to be supervised it may be necessary to add similar reactive metering. Modern system control technique places increasing emphasis on chart recorders, and the group control centre should have both group and station total load recorders. A mimic diagram showing all switches and machines is essential, preferably with automatic indication, but manual correction of the diagram can be employed if information can be readily and reliably telephoned. Busbar voltage readings are necessary for the main collecting point substation and for any individual power station from which direct distribution is given. All feeders should have ammeters for thermal supervision. For isolated systems it is essential, and for satellite groups desirable, to have accurate frequency indication and recording, with facilities for time error display.

Table I.—*Group Control Costs*

Method of control	Number of operating and maintenance staff required for the group	Cost, in thousands of pounds, of			
		Turbine control equipment, supervisory plant and cables	Salaries (15 years' capitalisation at an average of £450 p.a.)	Staff houses at £1500 each	Total for plant, salaries and housing
Local manual	120	56	810	180	1046
Local semi-automatic... ...	95	86	642	143	871
Local fully automatic ...	45	105	304	68	477
Remote fully automatic ...	45	110	304	68	482

The above cost comparison of control methods is for a hypothetical group comprising five two-machine power stations and one main substation, covering 10 miles, with group control administered from the substation site.

Hydraulic Information Required.—The primary quantities are reservoir levels (and tail-race levels when these are subject to large fluctuations), and they should be recorded as well as indicated, since undertakings often have statutory obligations which demand continuous supervision of certain river levels. From these readings a variety of quantities can be deduced. Topographic records enable the reservoir level to be translated into terms of storage capacity, and turbine efficiency factors will enable storage capacity to be converted into equivalent stored energy. Comparatively simple apparatus is available to weight the storage quantities for successive reservoirs, so that equivalent stored energy available throughout the chain of stations may be determined.

Whilst level readings indicate the presence of imminent or actual spilling conditions, it is desirable to add audible and visual warning when such discharges begin, and to record the duration and magnitude of the spill for "lost units" calculation. The movement of float-controlled flood gates or of a float device downstream from the dam may initiate the alarm.

It is common to establish rain gauges at representative points in the catchment area and to secure readings every day by telephone report. There is scope for developing simple automatic radio transmitters for inaccessible gauging sites to signal, say, after every 0·1in of rain has collected. The assessment of the

amount of run-off is assisted by daily reports of the levels in major streams.

An important new concept in group control is now being studied, whereby the maximum economy in the use of water can be ensured by running the various plants only at those loads at which their efficiency is highest under the conditions prevailing. In multi-machine stations such maximum efficiency points vary with the prevailing gross head and with the number of running machines, because of the variation in turbine characteristics and tunnel friction.

Conclusions

Load Factors.—Although the average load factor is predetermined for each power station, the future trend is difficult to foresee in many cases. An increase in load factor may arise from the direct addition of extra catchment or by new schemes discharging into an established storage system; conversely, a decrease may arise by the diversion of catchment to later and more profitable schemes. Sometimes the project may be planned for ultimate plant extensions, which again results in a lower load factor. Apart from such considerations, however, the average load factor may be achieved by a very wide range of daily operating characteristics, owing to seasonal variations of rainfall and demand and to the five-day week. In countries where hydro-electric power is essentially peak assistance to bulk generation by thermal plants, all hydro-electric stations are liable to be called upon for frequent short bursts at full load. Under such circumstances, rapidity of starting and loading is essential, and automatic control is the most favourable. The maximum flexibility is therefore desirable, as has been demonstrated elsewhere.[7] When a group contains a number of peak-load stations, fully automatic control is advisable, to achieve the most rapid loading.

The Case for Semi-Automatic Control.—All the factors discussed tend to favour semi-automatic control, whether the power station is to be attended or not. Such a solution clearly facilitates standardisation of equipment, with immense advantages both to manufacturers and to operation and maintenance staffs. At present a great deal of engineering time is occupied by control scheme work, with resultant delays and costs, but the authors' work convinces them that a standard design of control system can be achieved for almost all makes and types of turbine; moreover, the form of such equipment could readily be such as to admit the addition of automatic synchronising at will.

It may be added that twelve years' experience with semi-automatic control gear in the Galloway scheme has shown it to be an outstanding success.[8]

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R.M.S. "Oronsay."—The Orient Line announces that the damage done to the "Oronsay" by the recent fire is less extensive than anticipated and bookings have been reopened for the new sailing date, which will be about May 16, 1951.

American Engineering News

A Large Vacuum Flashing Unit

As part of a general modernisation programme at its Richmond refinery, the Standard Oil Company of California has awarded a contract for what is believed to be the world's largest vacuum flashing unit to the M. W. Kellogg Company. The unit will be able to charge 55,000 U.S. barrels of reduced crude per day. Its main vessel will be 80ft high and will have a maximum diameter of 27ft. Its design capacity is claimed to exceed by 15 per cent the largest vacuum unit in operation currently. The unit is being designed to provide approximately 30,000 barrels of feed per day for the existing catalytic cracking plant at the refinery. Asphalt—the other major product from the flashing unit—will be converted into high-grade fuel oil and petrol. The new plant is scheduled for completion in May, 1951.

The Pennsylvania Railroad Company

The Pennsylvania Railroad Company has placed orders for 214 diesel-electric locomotives, costing about 55,000,000 dollars. The order, which includes freight and passenger locomotives and shunting engines, is believed to be the largest ever placed for diesel-electric locomotives by any railway company. It will place the company considerably ahead of any other one in the use of diesel-electric power.

It is of interest to note that at the end of 1945 the Pennsylvania Railroad had only one passenger diesel-electric locomotive and thirty diesel and petrol-driven shunting engines. With the delivery of the locomotives now on order the company will have a total of 1034 diesel-electric locomotives, with an aggregate of 1,943,500 h.p. The company has announced that it will continue the use of steam power on a considerable number of its train operations where "dieselisation" is not justifiable economically.

The Brookhaven Atomic Pile

The largest atomic pile in America to be dedicated to pure research and investigations of a humanitarian nature has commenced operation at the Brookhaven National Laboratory at Upton, Long Island. Designed for an ultimate energy output of 720,000kWh per day, it will be fifteen times as powerful as the nuclear reactor at the Oak Ridge National Laboratory, the largest one of its kind until now. Apart from research into the fundamental nature of atom nuclei, the pile will be used to produce various radioactive isotopes, both for medical and for industrial purposes. Among the projects allied with the new reactor is a small research hospital where short-lived radioactive elements produced in the pile will be tested in the treatment of various types of cancer.

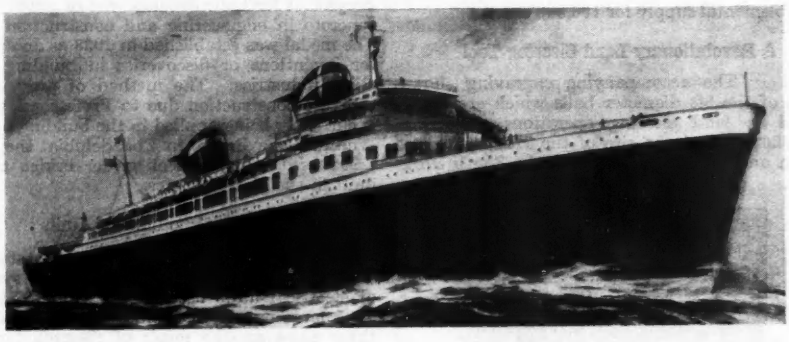
Cold Extrusion of Shells

In a report issued by the U.S. Army Ordnance Corps, satisfactory progress is announced in the setting up of production facilities for the cold extrusion of shells. In the first instance, the material being extruded is a plain carbon steel to S.A.E. 1010 specification, and the resulting shell is reported to have considerably better physical properties than had been expected. The shells being manufactured by this method are of the 105mm "M1" type, the size of which is being used by the U.S. Army in the largest quantities. After the successful completion of a production line for the 105mm shell, further facilities are to be developed for the production of 4½in rockets and 155mm shells. The main extrusion unit being employed currently is a 3000-ton hydraulic press.

Government Acquisition of Passenger Vessels

The U.S. Department of Defence has decided, on the recommendation of the Joint Chiefs of Staff, that four passenger vessels now under construction in the United States, are to be taken over by the government and to be completed as troop transports. The vessels involved are the 48,000-ton liner S.S. "United States," which was being built for the United States Lines, and three 15,000-ton sister ships, the "President Jackson," "President Hayes" and "President Adams," which were being built for the American President Lines.

Construction of the "United States" was started on February 8, 1950, and the vessel was estimated to take 1218 days to completion. The ship is being built in a graving dock of the Newport News Shipbuilding and Dry Dock Company at Newport News, Virginia, to the designs of Gibbs and Cox, of New York City. The "United States" will be 980ft long, have a beam of 101ft 6in and will be powered by steam turbines driving four screws. Her top speed has not been disclosed, but she was originally intended to operate at speeds in excess of 28 knots in order to meet a regular fortnightly sailing schedule from New York to United Kingdom and Continental ports. At that time it was planned to have the vessel in service by the summer of 1952 and to send her into the trans-Atlantic trade as a challenge to the "Queen Mary" and the "Queen Elizabeth." The vessel is the largest to be built in the United States and her cost is estimated at 70,373,000 dollars. The main factors enhancing the ship's military value are speed and certain structural details. She will be able to carry 12,000 to 14,000 troops at 28 to 30 knots for a distance of 10,000 miles without stopping for fuel, water or any other supplies. She will have a special safety hull, two independent engine-rooms and special strengthening for gun platforms



Artist's Impression of S.S. "United States"

Two large vessels now under construction, which are not affected by this government decision, are the sister ships "Independence" and "Constitution." They are being built for the American Export Lines at the yard of the Bethlehem Steel Company, at Quincy, Massachusetts; the "Independence" was launched on June 3, and the "Constitution" on September 16, 1950. Both liners will enter the New York-Mediterranean service in the early part of next year.

Canyon Ferry Dam, Montana

Placing of concrete has started on the Canyon Ferry Dam on the Missouri River, in Montana. This dam is the largest multi-

purpose concrete structure now under construction within the Missouri River Project by the Bureau of Reclamation and is also the first major unit of the project to be built in the State of Montana. It is estimated that a total of 400,000 cubic yards will be used in bringing the dam to a crest height of 212ft. The dam will have an eventual power generating capacity of 50,000kW and is intended also to provide major irrigation and flood control benefits. Ground was broken a year ago; first water storage is scheduled for the spring of 1953, and power production is to follow in the autumn of that year. The reservoir, which will be created by the dam, will have a storage capacity of 2,050,000 acre-feet and will extend 25 miles upstream, inundating the existing Lake Sewell. Canyon Ferry Dam will be a concrete gravity structure with a height of 212ft from foundation level and 172ft from normal stream bed level. It will have crest length of 1000ft, a crest width of 20ft and a crest elevation of 3807ft. The spillway is situated at the centre of the dam, and overflow is controlled by four radial gates, each 51ft by 34·5ft. The power station will be situated immediately adjacent to the dam, with three 13ft 6in diameter penstocks leading to the three turbo-generator units. The power plant is expected to provide an annual average generation of approximately 300,000,000kWh. The control of flood waters will facilitate the eventual irrigation development of about 310,000 acres of new land and a supplemental supply for 196,300 acres.

A Revolutionary Land Clearing Tool

The accompanying engraving shows one of the 8ft diameter balls which are being used in land clearing operations, involving 22,000 acres at the site of the Hungry Horse dam and reservoir project on the South Fork

TREE-FELLING STEEL BALL

of the Flathead River in north-western Montana. The balls are constructed of ¾in boiler plate and each ball has a 6in diameter steel shaft mounted in tapered roller bearings. Some ten gallons of oil are kept in the ball in order to provide for bearing lubrication. Initially the contractors concerned tried several methods of using the balls singly and in pairs. As a result of these experiments it was established that the fastest and most efficient method consisted of a single ball being pulled by a pair of tractors. In current operations the contractors are using approximately 200ft of 1¼in wire rope on each side of the ball. Winch cables from the two tractors are attached to the ends of the ball cable with swivel joints in order to prevent twisting and tangling of the cables. In making a "pull," the two tractor operators bulldoze their way through the timber on approximately parallel paths several hundred feet apart. The distance between the tractors varies with the kind of terrain and the size of the trees to be felled. Under light conditions the tractors move through the timber snagging down the trees caught in the loop of the cable as they progress. However, in heavy stands of fairly large trees special use is made of the tractor winches. The cable is permitted to unreel as the tractors move ahead through the timber until most of the cable on the winches has been paid out. The tractors are then anchored against trees or stumps and the cable on the winches is reeled in. The great increase in pull gained by using the winches in this manner makes it possible to pull down trees up to 4ft in diameter. This clearing method has been found capable of uprooting practically all of the large trees. Small trees frequently are only partially uprooted or are bent over without breaking. However, in bending the small trees the cable scrapes the bark from one side of the trees. As a result these small trees bleed and die rapidly, turning brittle, so that they are easy to stack and burn.

The Franklin Institute

The Franklin Institute, of Philadelphia, has awarded the Frank P. Brown Medal to Gustave P. R. Magnel and Eugene Freyssinet for their development of prestressed concrete in engineering and construction use. The medal was established in 1938 as an award for inventions or discoveries in building and allied industries. The method of prestressed concrete construction due to Professor Magnel is currently being applied in the building of the Walnut Lane Bridge in Philadelphia, the first prestressed concrete deck girder bridge to be built in the United States.

Electrical and Photometric Units

Congress has given formal statutory sanction to a revision of the practical system of electrical units used in the United States. To a large extent the values now adopted for these units are the result of research by the National Bureau of Standards, and the present legislation was actually proposed by the Bureau. The changes in magnitude of these units are small; in no case are they larger than $^1/_{20}$ of 1 per cent, but the new law puts the values on a clear and unambiguous basis, which facilitates the closest practicable agreement between electrical and mechanical units. In view of the comparative inaccuracy of the older definitions of the ampere, the ohm and the volt, the American Institute of Electrical Engineers proposed a return to the basic absolute units in 1928. It took twenty years of research and negotiations to bring about unanimous international action to this end. The new act defines the ohm as one thousand million units of resistance of the centimetre-gramme-second system of electromagnetic units, and the ampere as one-tenth of the unit of current of the centimetre-gramme-second system of electromagnetic units, with other electrical units being defined on the basis of these two units. With regard to photometric units, the candle is defined as one-sixtieth of the intensity of one square centimetre of a perfect radiator (black body) when operated at the temperature of freezing platinum; and the lumen as the flux in a unit of solid angle from a source of which the intensity is one candle.

Big Eildon Dam, Victoria

In the face of British, Australian and New Zealand competition, the Utah Construction Company, of Ogden, Utah, has obtained the 25,000,000 dollar contract for the construction of Big Eildon Dam on the Goulburn River in Victoria, part of the largest public works project in the history of Australia. With a crest length of half-a-mile and a height of 260ft, the dam will be one of the largest earth dams in the world. It will contain 13,000,000 cubic yards of earth and rock fill and involve 200,000 cubic yards of concrete work.

French Engineering News

(From our French Correspondent)

In West Africa the hydro-electric development of the Sotuba Falls is being investigated. The cost is likely to be high, however, so that the comparative merits of a thermal plant are also being studied. It is reported that the production of electricity in West Africa will be undertaken by the Occidental African Energy Corporation, which will be formed for that purpose. Meanwhile, the Niger-Dakar line is being electrified, using single-phase, 50 c/s current. This type of development may spread into other French possessions. It may be recalled that tests with a similar electrification scheme were recently carried out in France.

* * *

The S.N.C.F. has decided to equip 1000 level crossings with automatic signals, to replace the present hand worked barriers. The signals will comprise a powerful, flashing light, and the continuous ringing of a loud bell. The trains themselves will sound the signal as soon as they enter the level crossing zone. By eliminating the human element it is hoped to make the crossings safer. Plans for the replacement of level crossings have been prepared, but excessive cost and the time required have influenced the railways to adopt the automatic signal system.

* * *

A new prestressed concrete bridge is to be constructed in the north at Lille. It will be known as the Pont de l'Avenue de l'Hippodrome, and will have 67m long spans, consisting of eight beams with a total weight of 4200 tons. Construction is expected to be finished by the beginning of 1952.

* * *

Two 120kW transmitters are to be installed at Sebaa-Aioun, between Meknes and Fes, in Morocco. This is the first part of a programme on which work will be started early in 1951.

It is also planned to develop the water supply system of Casablanca. A storage dam will be built at Sidi-Said Machou, about 2km from the purification plant, to which water will be pumped at a rate of 90,000 cubic metres per day.

From this plant the water will be carried in conduits of 1m in diameter and 5km long to a compensation reservoir with a capacity of 16,000 cubic metres. At this point it will be connected to a 50km conduit which will be built in the second stage of the project, and which will carry water to outlying districts. Between the compensation reservoir and Casablanca, a consumption of 2000 litres per second is provided for. Work on the first stage of the scheme should be finished by the end of next year.

* * *

The *Journal Officiel* recently gave details of an electrical equipment programme which will be undertaken by Electricité de France. It includes a 220kV line from Carling, the new steel centre now under construction, to Laneuveville, and a 10kV line from Hendaye to Hougueerre. The programme also includes the establishment of a 150kV line and several 30kV lines.

* * *

A report on the French iron mines states that, while over the past eight months stocks of iron ores have increased, production has fallen, and modernisation of the mines has been held up through lack of credits and low prices. On the other hand, there has been some development in technique and methods due to Marshall Aid funds.

For the first eight months of this year some 19,162,207 tons of ore were mined, against 20,820,449 tons during the corresponding period last year. Personnel, which reached over 30,000 in 1949, dropped again in 1950 to just over 28,000. Output per man-hour has also dropped slightly except in the mines in the East of France, where mechanisation has been developed to a greater extent than elsewhere. Deliveries of ores have dropped for the first eight months of the year. For example, in 1949 the figure given was 32,560,384 tons, of which 25,451,914 tons were absorbed by the Saar. Up to August 31, 1950, however, deliveries were only 18,783,645 tons.

Industrial and Labour Notes

Trade Disputes

According to statistics compiled by the Ministry of Labour, there were 124 stoppages of work from industrial disputes in the United Kingdom, in progress at some time during the month of October. As a result of them, 40,300 workers were affected, directly and indirectly, and the aggregate number of working days lost was 246,000. The majority of the stoppages—seventy-five—occurred in the coal-mining industry. They involved 18,200 workers and caused a loss of 32,000 working days.

A Parliamentary question put to the Minister of Labour last week asked how many working days were lost in 1949 through industrial disputes and the percentages for nationalised and privately-owned industries. In his reply, the Minister stated that the aggregate number of working days lost through disputes last year was 1,807,000. About 46 per cent of that total was lost in stoppages in industries nationalised since 1945, and about 54 per cent in other industries.

Industry and Rearmament

The President of the Federation of British Industries, Sir Robert Sinclair, addressed a luncheon meeting of F.B.I. members in Glasgow on Thursday of last week. In the course of that address Sir Robert pointed out that room had to be made in the national economy—already considerably strained—for a defence programme. That, he said, presented both physical and financial problems, the solution of which must be a first charge on our resources. If, as he hoped, industry could be consulted and given adequate information on which to measure and arrange to overcome the difficulties, Sir Robert felt sure that the experience possessed by industry could and would be harnessed to secure that the programme was achieved with the minimum of friction and the minimum of controls and regulation. That was the objective of the Federation's Defence Programme Committee.

Our economy, Sir Robert continued, must be braced to take the strain of increased expenditure on defence and to do that required better understanding, still harder work and wise guidance. A policy which sought to pay the price by further taxation was simply mortgaging the future and his conviction was that some way must be found of aligning material incentive with national needs. Sir Robert went on to assert that the most important contribution industry could make was to pursue without ceasing the objective of greater efficiency and higher productivity. In many cases, he acknowledged, firms which had in part to switch production from civil to defence needs and had to re-tool in the process, must find their productivity, as well as their production, for a time, adversely affected. As rising costs and shortages in some raw materials were now other handicaps to be overcome, the need for every possible improvement was greater than ever. In those circumstances, Sir Robert claimed, to find some way of giving reasonable reward for better or harder work, for skill and for enterprise, was urgently necessary.

Current Industrial Problems

A statement by Mr. W. Edgar Hale, chairman of Hale and Hale (Tipton), Ltd., which is included in the company's annual report, comments on the "very silly notion, decidedly prevalent, that there is something immoral and wrong about the making of profit from industry." Industry, Mr. Hale says, can never be in a worse possible state than when it ceases to make profit, for profit provides the money whereby industry can be extended, and as the result of being provident with resources, any surplus there may be can be invested in other enterprises to start new operations.

To-day, the statement observes, the heads of all commercial enterprises are constantly having to exercise their minds on the relationship of their financial resources with current costs of plant replacement and extensions. With taxation at its present level that presents a very grim picture and one which should be considered, Mr. Hale says, with the greatest care at the highest possible level, with a view to relieving the tax burden to some extent, where profits are being absorbed into maintenance and development. Industry, as a whole, Mr. Hale states, is making good profits and should contribute adequately to the maintenance of exchequer funds, thereby contributing its quota to the well-being of everyone. But, he asserts, if that process is to continue, it is of paramount importance that the finance of industry should be kept in a virile state, and he expresses the hope that the Chancellor of the Exchequer in the very near future will see the logic of bringing about desirable changes.

Interim Index of Industrial Production

The index number of industrial production (1946=100), which is prepared by the Central Statistical Office, has been estimated provisionally at 144 for September, compared with 124 for August. Figures for the corresponding months of last year were 132 for September and 119 for August. Taking the manufacturing industries, the index number for September this year is put provisionally at 150, compared with 136 in September, 1949.

The Economic Information Unit of the Treasury says that, from information so far received, the index for all industries for October is expected to be 146 or 147. On the basis of that estimate, therefore, industrial production was 8 per cent higher than in October, 1949. Taking the first ten months of the present year, industrial production was about 8 per cent higher than in the corresponding period of last year.

Metal Scrap and Local Authorities

A circular has been sent to local authorities by the Ministry of Health reminding them that the Iron and Steel Scrap Order, which came into operation in September, increased by 10s. per ton the maximum delivered prices at which compressed destructor scrap suitable for melting in blast-furnaces for producing pig iron could be sold. The maximum prices at which such scrap can be sold to blast-furnaces varies according to the situation of the furnace. The prices per ton are as follows: —County Durham and North Riding of Yorkshire, 64s. 6d.; Cumberland and North and South Lancashire, 59s. 6d.; Derbyshire, Nottinghamshire, Leicestershire and Sheffield district, 60s. 6d.; Lincolnshire, 63s.; North Staffordshire and Shropshire, 62s. 3d.; South Staffordshire and Worcestershire, 57s.; Northamptonshire, 57s.; Essex, 52s. 3d. These prices include the cost of delivery to the furnaces.

The circular points out that in the past local authorities have been a valuable source of supply of this class of scrap, and it is hoped the increase in prices will encourage some to extend operations in this direction. The expansion of the blast-furnace capacity of the country is, of course, increasing the need for supplies of destructor scrap which, although not a particularly good class of ferrous scrap, can when melted with other raw materials, significantly increase the output of pig iron. Steel makers and representatives of the Scrap Merchants' Federation have appointed joint district scrap committees to deal with any special problems which may arise, and the circular gives a list of the chairmen of those committees. Advice of a general character can be obtained by local authorities from the Ministry of Supply, Iron and Steel Division, Bush House (S.W. Wing), Strand, London, W.C.2.

The Industrial Welfare Society

The annual general meeting of the Industrial Welfare Society was held at the Society's new premises at 48, Bryanston Square, London, W.1, on Tuesday last. The annual report of the council indicates many extensions to the Society's work during the past year, but emphasises, at the same time, that, despite vast changes in organisation and outlook in British industry in recent years, every activity now being pursued by the Society still fits into its original concept. During the year the Society arranged sixteen residential conferences, which were attended by 1951 delegates. Other meetings in London and the provinces were attended by nearly 3400 people.

Speaking at the annual meeting, Lord Trent, the President, said that welfare had become very much a topic of the day, both nationally and in industry. People at all levels in industry were looking to the Society for advice and guidance. It was noteworthy and very welcome to the Society, Lord Trent added, that the trade union movement was becoming increasingly interested in industrial welfare. Lord Trent went on to say that there was a school of thought which held the view that what was loosely called "industrial welfare" was purely a facet of the job of the specialist in personnel management. Those who held that view believed that welfare was a managerial function, like sales promotion or market research, but, Lord Trent pointed out, human relations at work constituted a two-way traffic. Management and workers both had a vital part to play in dealing with human hopes, failings and achievements. An important consideration was not only how to teach people to lead in life, but how to inculcate response to leadership, which was a much more delicate process.

The Coal Situation

The executive committee of the National Union of Mineworkers passed a resolution, on Thursday of last week, urging miners in all areas to work an extra shift on Saturdays in order to increase the country's coal output. It will be recalled that Saturday working was reintroduced in 1947, under an agreement on extension of hours made between the union and the National Coal Board, and since then has been the practice in a number of collieries. In some of them, however, the additional shift is worked only in alternate weeks. The union executive's decision, it appears, was made after a discussion on the coal shortage and the declining manpower in the industry.

Further discussion on these matters has taken place during this week and there has been another meeting of the manpower committee of the National Consultative Council for the industry. The committee has now completed its review of manpower and recruitment, and will present a report on the subject to the Consultative Council on December 13th. Meanwhile, the latest figures issued by the Ministry of Fuel and Power show that, in the week ended December 2nd, output of deep-mined coal was 4,352,500 tons and of opencast 157,900 tons, giving a total of 4,510,400 tons.

Although that total was below the figure achieved in the corresponding week of last year, it shows some improvement when compared with the outputs of recent weeks. From reports which have been made this week there was an immediate response at several pits to the union's suggestion and more shifts were worked last Saturday. In addition, the Ministry's figures reveal—for the first time for many months—a slight improvement in the manpower situation. In the week ended November 25th the total number on colliery books was 686,600, of whom 284,400 were working at the face. But a year ago there were 293,600 face workers.

Personal and Business

THE SKEFKO BALL BEARING COMPANY, Ltd., has opened a new branch office at 28, Magdalen Street, Exeter (telephone, Exeter 4353). Mr. E. A. Phillips is in charge.

STRAMIT BOARDS, Ltd., announces the appointment of Mr. G. W. H. Haines, 269, Ferndale Road, Swindon, as technical representative for the Southern counties.

TUBE INVESTMENTS, Ltd., states that Mr. D. Lacy-Hulbert, B.Sc., A.R.I.C., has been appointed joint managing director of its subsidiary, Chesterfield Tube Company, Ltd.

MR. H. ADAM, M.I.Mech.E., has taken up an appointment in the waterworks section, planning and design branch, in the Public Works Department, Government of Cyrenaica.

ROBEY AND CO., Ltd., Lincoln, announces the appointment of Mr. Frank W. Bell, A.M.I.Mech.E., as an additional managing director, to act jointly with Mr. W. T. Bell, the present chairman and managing director.

TUBE INVESTMENTS, Ltd., has completed negotiations for the acquisition of a substantial interest in the Standard Tube Company, Ltd., Woodstock, Ontario, Canada. The company is to be renamed the Standard Tube and T.I., Ltd.

SAMUEL OSBORN AND CO., Ltd., Sheffield, announces the following appointments:—Mr. C. A. Malone, director of Burys and Co., Ltd.; Mr. John H. Osborn and Mr. R. F. Horton, directors of Osborn Foundry and Engineering Company, Ltd.

MR. MATTHEW SEAMAN, M.I.Mech.E., has relinquished his appointment as director and general manager of David Brown-Jackson, Ltd., Manchester, on being appointed general manager of the engineering works of the British Oxygen Company, Ltd., Edmonton.

MR. DENIS W. M. ALLEN has been appointed a director of W. H. Allen, Sons and Co., Ltd., Bedford. He is a grandson of Sir Richard Allen, the chairman of the company, and great grandson of the late Mr. W. H. Allen, the founder and first chairman of the company.

LAMSON ENGINEERING SOUTH AFRICA (PROPRIETARY), Ltd., is the title of a company incorporated to operate independently the Lamson agency hitherto held by Associated Engineers Company, Ltd. The new company will operate under the management of Mr. S. Tyrie, at present manager of the Lamson department of Associated Engineers Company, Ltd.

THE RAILWAY EXECUTIVE announces the appointment of Mr. R. F. Harvey as chief officer (motive power), in succession to Mr. H. Rudgard, who has retired. The Executive also announces the appointment of Mr. F. D. Y. Faulkner as public relations and publicity officer, Southern Region, Waterloo, in succession to Mr. C. Grasemann, who will retire at the end of this month.

DARLING AND SELLERS, Ltd., Keighley, has been taken over jointly by D. Mitchell and Co., Ltd., Keighley, and Rushworth and Co., Sowerby Bridge. Mr. P. L. Crabtree, Mr. John W. Rushworth, Mr. C. Donald Rushworth, and Mr. S. Wilson have been appointed directors. Morrison, Marshall and Hill, 44–45, Tower Hill, E.C.3, will act as the London office and export division of Darling and Sellers, Ltd.

Launches and Trial Trips

EGYPTIAN PRINCE, cargo motorship; built by the Burntisland Shipbuilding Company, Ltd., for the Prince Line, Ltd.; length between perpendiculars 345ft, breadth moulded 51ft, depth moulded 30ft 9in, deadweight 4600 tons; Hawthorn-Doxford oil engine, four cylinders, 600mm diameter by 2320mm, combined stroke, 3300 b.h.p. Launch, September 27th.

MANCHESTER MERCHANT, cargo liner; built by Blythswood Shipbuilding Company, Ltd., for Manchester Liners, Ltd.; length 440ft, breadth 59ft, depth 38ft 4in, deadweight 8600 tons; one set of single reduction geared turbines taking superheated steam from three cylindrical boilers, service speed 14½ knots. Launch, September 27th.

BRITISH PROSPECTOR, motor tanker; built by Harland and Wolff, Ltd., for the British Tanker Company, Ltd.; length between perpendiculars 463ft, breadth moulded 61ft 6in, depth moulded 34ft, deadweight 12,300 tons; Harland-Burmeister and Wain single-acting, four-stroke diesel engine, six cylinders, 740mm diameter by 1500mm stroke, 115 r.p.m. Trial, September 28th.

NINA, motor coaster; built by Chantiers et Ateliers Augustin Normand for the Ministry of the Merchant Marine; length b.p. 59·4m, breadth moulded 9·3m, depth 5·6m, displacement 1557 tons; M.A.N. diesel engine, 750 b.h.p. at 180 r.p.m. Launch, September 28th.

Notes and Memoranda

Air and Water

MERCHANT SHIPPING ACT.—The Minister of Transport has made an order bringing into force the Merchant Shipping Act, 1950, which provides for the continuance of arrangements for the engagement and discharge of merchant ships' crews. It also enables new regulations to be make concerning crew accommodation in fishing-boats.

THE SHIPPING FEDERATION.—The executive council of the Shipping Federation has appointed Mr. Donald F. Anderson, who is deputy chairman of the P. and O. Steam Navigation Company, as chairman, in succession to Mr. Basil Sanderson, who has held that position since 1934. Sir Arthur Sutherland, Bart., the president since 1938, did not seek re-election and Mr. Basil Sanderson was appointed as his successor.

CARRIAGE OF SOLID BALLAST.—The Ministry of Transport has carried out an investigation into the properties of solid ballast and the precautions necessary to prevent a dangerous shift. The results obtained and suggestions for desirable precautions have been made available in Notice No. M347, "Seaworthiness and the Carriage of Solid Ballast," copies of which can be obtained from the Ministry of Transport, Berkeley Square House, London, W.1.

Miscellanea

OIL AND INDUSTRY.—A film entitled "Oil and Industry," has been made for Shell-Mex and B.P., Ltd., by Trident Films, Ltd., which illustrates the vital tasks which oil performs in this machine age. The main theme is lubrication, where the wide range of application is emphasised by views of a watch mechanism, a dredger ladder and of operational use under conditions of extreme cold and heat. Other functions are illustrated, such as the transmission of power, electrical insulation, machine cutting coolant, quenching and as a corrosion inhibitor. The film contrasts machinery existing when oil was discovered with that of to-day and gives a cross section of the oil industry, including views of wells, pipelines, tankers, research laboratories and refineries.

NEW GENERATING STATION AT LERWICK.—A White Paper now published gives particulars of a constructional scheme promoted by the North of Scotland Hydro-Electric Board, approved by the Right Hon. Hector McNeil, M.P., Secretary of State for Scotland, and laid before Parliament. The scheme provides for the construction of a diesel generating station at Lerwick, with a capacity of 6000kW, to meet the growing demand for electricity in the Shetland Islands; it is estimated to cost £248,000. There were no objections to the scheme. The Fisheries Committee made no recommendations and the final design of the power station was accepted by the Amenity Committee. Copies of the White Paper (price 1d.) are obtainable from H.M. Stationery Office, 13a, Castle Street, Edinburgh, 2, or through any bookseller.

THE USE OF SILICONE IN A LIQUID POLISH.—The application of 4 per cent silicone to a liquid base has formed a polish which imparts to a surface the basic properties of silicone itself. This polish, known as "Autobrite," is shortly to be manufactured in this country by E. R. Howard and Co., Ltd., and during a recent demonstration we were able to observe its effectiveness on enamelled cellulosed and glass surfaces. The polish was applied with an ordinary cloth without cleaning the surface and allowed to dry before rubbing over. A durable glass-like surface was deposited, which imparts a highly glossed finish and is guaranteed by the makers to last six months. During this period no further polishing is required, rain or hose water being sufficient to restore the finish. It is claimed that the surface does not crack or craze, and is resistant to moisture, heat, dust and oxidisation. Its use on glass prevents surface scratching and staining.

MICROWAVE TELEVISION LINKS FOR THE B.B.C.—We learn that the British Broadcasting Corporation has placed an order with Marconi's Wireless Telegraph Company, Ltd., for six sets of permanent or mobile microwave television links, to be used in the transmission of television programmes from places outside the cable system of Alexandra Palace. These links comprise a miniature transmitter or receiver (measuring 14½in by 17½in by 14in) mounted at the rear of a parabolic reflector 4ft in diameter, carried on a tripod for mobile use. The rest of the equipment can be packed into suitcase units and can be set up quickly and orientated accurately. A transmitter and receiver can be situated 200ft from each other connection being made through a single multicore cable. The equipments are designed to work within the band 6500 to 7050 Mc/s and use wide-band frequency modulation. Intercommunication facilities are embodied in these links; a standard headset can be plugged in for telephonic communication by line or separate radio link with other units and to other mobile equipment, the studio or the transmitter. The operating range of the equipment, over a line-of-sight path, is from 15 to 20 miles, but it is stated satisfactory operation has been obtained up to 40 miles.

CHILDREN'S CHRISTMAS LECTURE ON ELECTRICITY.—A Christmas lecture for older schoolchildren, on the subject of "The Electrical Current, its Action and Nature," will be given at 3 p.m. on January 2 and 3, 1951, in the lecture theatre of the Institution of Electrical Engineers, London. The lecturer will be Dr. W. Wilson, manager of the Development Laboratory of the General Electric Company, Ltd., Witton, and his address will be illustrated by some twenty-five or thirty experiments to illustrate the properties and applications of electric currents, and the flow of electrons through gases.

A TURBO-GENERATOR SET FOR CANADA.—The Nova Scotia Light and Power Company has placed an order with Metropolitan-Vickers Electrical Company, Ltd., for a 20MW, 3600 r.p.m., turbo-generator set complete with condenser and feed water heaters, to be installed in the existing station at Halifax, Nova Scotia. The turbine will be a single-cylinder machine, designed for initial steam conditions of 600 p.s.i.g., 800 deg. Fah. The condenser is designed to give a vacuum of 28·75in Hg., and four-stage feed heating will give a final feed temperature of 340 deg. Fah. both at the economic load of 16MW. The generator will be a three-phase, 60 c/s machine, air-cooled and direct driven at 3600 r.p.m.

RUBBER POWDER IN ASPHALT ROADS.—The British Rubber Development Board has recently issued a booklet on the use of rubber powder in asphalt roads. It contains a history of the research associated with this particular application of rubber to road surfacing, whereby rubber provided in particle form is used as a filler to tar and bituminous aggregates. Conditions of mixing and heating are contained in Chapter I, giving critical temperatures, on which depend the quantity of rubber to enter into solution. The remainder exists as swollen rubber particles and it is thought that these absorb the lighter fractions of the bitumen, which otherwise, under the influence of heat and traffic, rise to the road surface ("bleeding"), where they become dissipated to the future detriment of the bitumen as a surface. Rubber also raises the softening point of the bitumen. The booklet concludes with a chapter on the road surfacing with rubber/bitumen already carried out in Great Britain for test purposes. Free copies of this booklet may be obtained from the Board's offices.

Contracts

DISTINGTON ENGINEERING COMPANY, Ltd., Workington, Cumberland, has received an order, valued at over £300,000, for mine cars to be used in three groups of coal mines in Turkey.

R. J. SPARGO (PTY.), Ltd., Johannesburg, South African associates of Wilkinson Rubber Linatex, Ltd., Camberley, Surrey, has secured orders for all the abrasion resisting pumps required by the Free State Development and Investment Corporation, Ltd. About sixty-two Linatex pumps are involved, in value about £30,000, sizes ranging from 3in to 12in discharge.

FERGUSON BROTHERS (PORT-GLASGOW), Ltd., has received an order for another tug for the Clyde Shipping Company, Glasgow, which brings the number of vessels at present building for these owners up to three. The same firm has also received an order, through the Crown Agents for the Colonies, for a single-screw grab hopper dredger for the Government of Malta.

GILBERT GILKES AND GORDON, Ltd., Kendal, has received an order for two 215kVA hydro-electric units for installation at the Elan Valley Waterworks of the City of Birmingham Water Department. They will replace the 60kW "Gilkes" turbines, which are now more than forty-five years old. The turbines are to be of the spiral-cased Francis type, suitable for operating under a head which may, under extreme conditions, vary from 103ft to 45ft.

British Patent Specifications

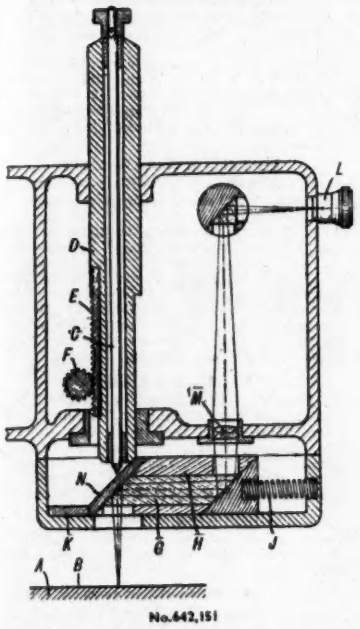
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

MACHINE TOOLS

642,151. October 2, 1947.—IMPROVEMENTS IN AND RELATING TO A PRECISION MACHINE TOOL, the Société Genevoise D'Instruments de Physique, 8, rue des Vieux-Grenadiers, Geneva, Switzerland.

The invention relates to a machine tool described in the Specification No. 633,031. This machine tool is characterised by the fact that the movable part of a microscope is submitted to the action of a spring which tends to keep it in working position. An inclined plane on the movable part is engaged by the marking tool when the tool is brought to its working position, in order to produce the automatic retraction of movable parts. The advantage of this design is that both the marking tool and the microscope can be used successively at any point of the workpiece without having to displace manually the movable part of the microscope. In the accompanying drawing the workpiece is at *A* and the surface which is to



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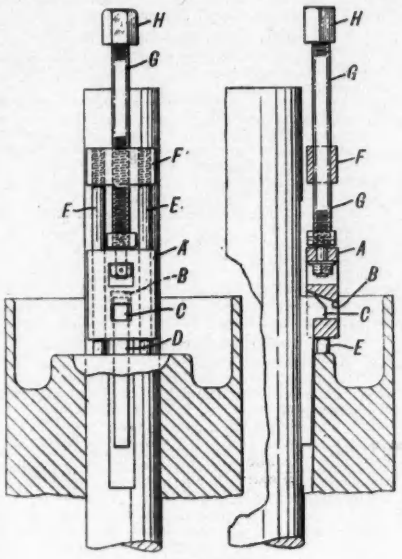
be observed with the microscope is at *B*. The marking tool *C* is mounted in a sliding sleeve *D*, on which is secured a rack *E*. A pinion *F*, controlling the vertical sliding movement of the tool, is manually operable. The microscope comprises a double prism *G* mounted in a carriage *H*. The carriage is pushed to the left by a coil spring *J* and an abutment *K* stops it in a predetermined position for the observation of the ocular *L* through the objective *M*. The left end of the carriage presents an inclined plane *N*, which can come in contact with the sleeve *D* of the tool. When the marking tool is being lowered for bringing it into working position, the sleeve pushes the carriage *H* to the right. If the marking tool is brought back to its rest position the spring *J* gives the carriage its movement to the left. The operation of the pinion has therefore the effect of enabling an observer to use the marking tool or to observe with the microscope without any further operation. —*August* 30, 1950.

TOOLS AND WORKSHOP APPLIANCES

642,234. July 23, 1948.—IMPROVEMENTS RELATING TO GIB KEY EXTRACTORS, Percy Sydney Moore, of 5, Worlingham Road, East Dulwich, London, S.E.22.

The extractor for gib keys used for connecting pulleys or the like to shafts comprises a block *A* with a recess *B* at one end for receiving the head *C* of the gib key *D* to be extracted. The block is formed with two bores, parallel to the gib key, the bores being adapted to receive a pair of pins *E* which can be projected to bear against the article on either side of the key. The other ends of the pins extend from the other end of the block and are held in a second block *F*. A threaded spindle *G* is screwed through the second block and is rotatably secured in the body block. Through a head *H* the spindle can be turned by a spanner. In operation the free ends of the pins *E* are retracted into the body block to enable



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the head of the gib key to be engaged in the recess *B*. The spindle *G* is then turned to force the free ends of the pins against the part in which the gib key is engaged. This forces the body block *A* to be retracted and to draw the gib key from engagement.—*August* 30, 1950.

MISCELLANEOUS

643,857. January 23, 1947.—EXTRUDING APPARATUS FOR FORMING TUBES OF UNIFORM INTERNAL DIAMETER AND HAVING AN EXTERNAL DIAMETER VARIABLE ALONG THE LENGTH OF THE TUBE, Compagnie Generale du Duralumin et du Cuivre, 23–25, Avenue Franklin Roosevelt, Paris, France.

Fig. 1 is a sectional view showing the parts in the positions they assume at the beginning of the tube-forming process, and Fig. 2 is a similar view at the end of the tube-forming process. In the drawing *A* indicates the compression cylinder of an extrusion press and *B* is the ram of the press. The metal billet *C* is inserted into the cylinder between the

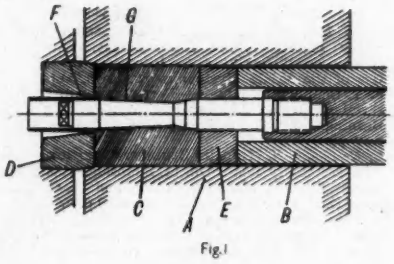

Fig. 1

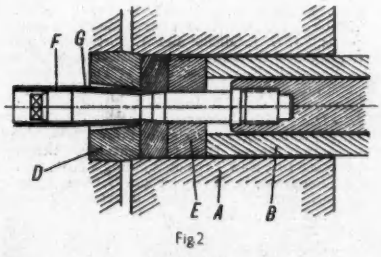

Fig. 2

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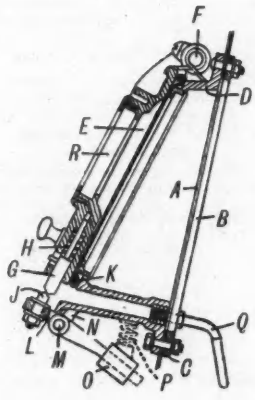
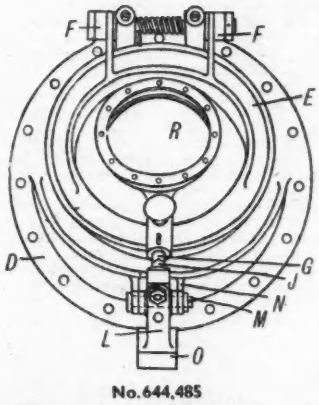
die *D* and a presser plate *E*, actuated by the ram to force the material of the billet through the die. At the start of the tube forming process, the metal is extruded between the die and the cylindrical part *F* of the mandrel as shown, so that the first portion of the tube formed is of uniform diameter and thickness. As the process continues, the mandrel advances so that its conical part *G* moves progressively through the die. The effective diameter of the mandrel is thus progressively reduced, so that the thickness of the tube formed is progressively increased, whilst the internal diameter of the tube remains uniform. By relatively simple calculations a fixed rule can be obtained for determining the relation between the variation of the diameter of the conical part of the mandrel and the variation of the external diameter of the tube produced.—*September* 27, 1950.

INTERNAL COMBUSTION ENGINES

644,485. July 9, 1948.—IMPROVEMENTS IN OR RELATING TO SAFETY DOORS FOR ENGINE CRANKCASES, Cuthbert Coulson Pounder, and Sir Frederick Ernest Rebbeck, of Harland and Wolff, Ltd., Queen's Island, Belfast.

This invention relates to safety doors fitted to the closed crankcases of reciprocating engines, for the purpose of relieving the pressure in the event of an explosion or excessive pressure. It provides an improvement in the metal safety door hinged at its upper end to a supporting frame, and inclined at such an angle that the door is self-closing under its own weight and is normally held closed by a catch adjusted to yield under excessive pressure in the crankcase. In the drawings, the line of the inclined side of the engine crankcase is indicated at *A* and *B* indicates an opening formed by a rim *C*. Secured to the rim is a door frame *D* supporting a door *E* in an inclined position, the door being suspended at its upper end by means of a hinge *F*. Mounted in the lower edge of the door is a catch or projection *G* pressed outwards by a spring *H*. The catch has a double bevel at its end corresponding with a double bevel on the end of a keeper of detent *J*. A resilient packing strip *K* is fitted to ensure the requisite gas-tight joint between the door frame and the door. All these details are of known construction. Heretofore it has been usual to fix the detent *J* to the door frame, with the result that, if the catch *G* fails to yield





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when the pressure inside the crankcase becomes excessive, the door will not open. According to the present invention the detent *J* is carried at one end of a rocking lever *L*, which is pivoted on a pin M in bosses *N* on the door frame and the rear end of the lever carries a counterweight *O* of such a size that, if the catch *G* fails to yield inwards at the required pressure, the bevelled end of the catch will trip the lever by slipping over the bevelled end of the detent, which yields downwards and lifts the counterweight. When the door returns to its closed position, the bevelled end of the catch rides over the end of the detent, tripping the lever. The inclination of the lever and the magnitude of the weight should be so arranged and proportioned that the door will not open unintentionally. If desired, a spring, indicated

in broken lines at *P*, can be introduced between the counterweight and the door frame to counteract inertia effects which may be experienced on shipboard in a heavy sea. The door frame may be hollow at, and communicate in known manner with, a U-pipe *Q* within the crankcase, to permit any oil droplets which leak through the joint of the door frame to be returned to the crankcase. The U-pipe *Q* may also serve as a warning if the pressure becomes excessive inside the crankcase by ejecting to the external atmosphere the oil collected in the bend of the U-pipe and blowing out to atmosphere vapour and oil mist. The door is preferably fitted with a window *R*, of any suitable transparent or translucent material.—*October* 11, 1950.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Tues., Dec. 12th.—S.W. LONDON BRANCH: St. George's Hall, St. George's Road, Wimbledon, "Colliery Electrification," R. A. Frith; "Industrial Psychology and the Electrical Engineer," G. S. Gorringe, 8.15 p.m.

Wed., Dec. 13th.—BIRMINGHAM BRANCH: Chamber of Commerce, New Street, Birmingham, "Modern Electro-Plating," A. F. Brockington, 7 p.m.——COVENTRY BRANCH: Technical College, The Butts, Coventry, "Recent Developments in Motor-Car Electrical Equipment," W. Cooke, 7.15 p.m.——BRADFORD BRANCH: Midland Hotel, Bradford, "Stage Lighting and Effects," J. H. Greenwood, 7.30 p.m.——KENT BRANCH: Royal Star Hotel, Maidstone, "Domestic Refrigeration," R. Sisley, 8 p.m.

British Institution of Radio Engineers

Wed., Dec. 13th.—N.E. SECTION: Neville Hall, Westgate Road, Newcastle, "A Survey of Television Development and its Problems," H. J. Barton Chapple, 6 p.m.——S. MIDLANDS SECTION: College of Technology and Arts, Rugby, "Electronic Circuitry," G. J. Scoles, 7 p.m.

Fri., Dec. 15th.—LONDON SECTION: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1, discussion, "Progress in Loudspeaker Design," opened by R. L. West, 6.30 p.m.

Chemical Society

Thurs., Dec. 14th.—Burlington House, Piccadilly, London, W.1, meeting for the reading of original papers, 7.30 p.m.

Diesel Engine Users Association

Thurs., Dec. 14th.—Caxton Hall, Westminster, London, S.W.1, "Report on Heavy-Oil Engine Working Costs, 1948–49," 2.30 p.m.

Engineers' Guild

Thurs., Dec. 14th.—Caxton Hall, Westminster, London, S.W.1, film, "Atomic Physics," 6 p.m.

Fri., Dec. 15th.—YORKSHIRE BRANCH: Royal Victoria Station Hotel, Sheffield, speaker, J. R. Rylands, 7 p.m.

Illuminating Engineering Society

To-day, Dec. 8th.—CARDIFF CENTRE: South Wales Electricity Board, The Hayes, Cardiff, "Stage Lighting," E. Faraday, 5.45 p.m.

Tues., Dec. 12th.—Lighting Service Bureau, 2, Savoy Hill, W.C.2, "The Development of the Tungsten Lamp," B. P. Dudding, 6 p.m.——GLASGOW CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Brains Trust," 6 p.m.——STOKE-ON-TRENT GROUP: 31, Kingsway, Stoke-on-Trent, "Lighting of Architecture," G. Grenfell-Baines, 6 p.m.

Wed., Dec. 13th.—EDINBURGH CENTRE: Lighting and Cleansing Department, High Street, Edinburgh, "Lighting for Celebrations," C. J. King, 7 p.m.

Thurs., Dec. 14th.—GLOUCESTER AND CHELTENHAM CENTRE: Cadena Cafe, Eastgate Street, Gloucester, "Sports Lighting," D. E. Beard, 6.30 p.m.——LEICESTER CENTRE: Electricity Board, Charles Street, Leicester, "The Electronic Flash Tube," A. J. Meadowcroft, 6.30 p.m.——MANCHESTER CENTRE: Town Hall Extension, Manchester, Presidential Address, L. J. Davies, 6 p.m.

Incorporated Plant Engineers

Mon., Dec. 11th.—DUNDEE BRANCH: Mathers Hotel, Dundee, "Small Air Compressors for Pneumatic Tools," J. Lake, 7.30 p.m.

Wed., Dec. 13th.—E. MIDLANDS BRANCH: Welbeck Hotel, Nottingham, "The Burning of Coke by the Downjet Method," G. C. H. Sharpe, 7 p.m.

Thurs., Dec. 14th.—KENT BRANCH: Technical College, Maidstone, "Thermostatic Control," T. W. Palk, 7 p.m.

Institute of British Foundrymen

To-day, Dec. 8th.—BIRMINGHAM AND WEST MIDLANDS STUDENTS' SECTION: County Technical College, Wednesbury, "Pattern Making," F. Grew, 7.15 p.m.

Sat., Dec. 9th.—NEWCASTLE-ON-TYNE BRANCH: Neville Hall, Westgate Road, Newcastle-on-Tyne, discussion on the Report of the Grey Ironfounders' Productivity Team, 6 p.m.——SCOTTISH BRANCH: Technical College, George Street, Glasgow, "The Repair and Reclamation of Grey Iron Castings by Welding and Allied Methods," 3 p.m.——WEST RIDING OF YORKSHIRE BRANCH: Technical College, Bradford, discussion on the Report of the Grey Ironfounders' Productivity Team, 6 30 p.m.

Tues., Dec. 12th.—COVENTRY AND DISTRICT STUDENTS' SECTION: Technical College, Coventry, "Recent Experiences of American Light Alloy Casting Production," J. Sulley and H. J. Millward, 7.15 p.m.

Wed., Dec. 13th.—LANCASHIRE BRANCH: Engineers' Club, Albert Square, Manchester, "Core Blowing," G. W. Fearfield, 7 p.m.

Thurs., Dec. 14th.—LINCOLNSHIRE BRANCH: Technical College, Lincoln, "Maintenance of Plant and Equipment," J. 1. Blackbourn, 7.15 p.m.

Institute of Industrial Supervisors

To-day, Dec. 8th.—CARDIFF SECTION: Park Hotel, Cardiff, Brains Trust on General and Topical Subjects. 7 p.m.

Tues., Dec 12th.—DUDLEY AND DISTRICT SECTION: Stewarts and Lloyds, Ltd., Coombes Wood Tube Works, Halesowen, "Planning for Production," J. E. Lawrence, 7.30 p.m.——KIDDERMINSTER SECTION: Carpet Trades, Ltd., Mill Street, Kidderminster, "The Foreman and Production Control," S. Waugh, 7.30 p.m.

Thurs., Dec. 14th.—LEEDS SECTION: Great Northern Hotel, Leeds, "The Foreman and the Cost Office," C. S. Paylor, 7.30 p.m.——NEWARK-ON-TRENT SECTION: Technical College, Newark, "Joint Consultation," T. G. Austin, 7.30 p.m.——BRISTOL SECTION: Central Hall, Oldmarket, film show, "Industrial Handling," "Steel," 7.30 p.m.——COVENTRY SECTION: Geisha Cafe, Hertford Street, Coventry, discussion, "The Position of the Foreman in British Industry," 7.30 p.m.

Institute of Marine Engineers

Tues., Dec. 12th.—85, The Minories, London, E.C.3, "Safety at Sea, 1850–1950," Denis O'Neill, 5.30 p.m.

Thurs., Dec. 14th.—Municipal Technical College, Hull, "Launching of Ships," R. S. Hogg, 7.30 p.m.

Institute of Metals

Mon., Dec. 11th.—SCOTTISH LOCAL SECTION: Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, "Non-Ferrous Metals in the Locomotive Industry," J. D. Glen, 6.30 p.m.

Thurs., Dec. 14th.—SHEFFIELD LOCAL SECTION: Grand Hotel, Sheffield, "The Isothermal Transformation of Copper-Base Alloys," R. Haynes, 6.30 p.m.

Institute of Navigation

Fri., Dec. 15th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Psychological Aspects of Instrument Presentation," H. P. Ruffell Smith, 5 p.m.

Institute of Road Transport Engineers

Tues., Dec. 12th.—E. MIDLANDS BRANCH: Engineers' Institute, Nottingham, "Fuel Injection," W. J. Brown, 7.30 p.m.

Thurs., Dec. 14th.—Royal Society of Arts, John Adam Street, W.C.2, "The Heating and Ventilation of Road Transport Vehicles," F. W. Duncombe, 6.30 p.m.

Fri., Dec. 15th.—S. WALES GROUP: Institute of Engineers, Park Place, Cardiff, "Recent Developments in Rear Axles," T. R. Beady, 7 p.m.

Institution of Civil Engineers

To-day, Dec. 8th.—N.E. STUDENTS' SECTION: King's College, Newcastle-upon-Tyne, "Switchgear for E. H. V. Transmission," R. W. Gee, 6.30 p.m.

Tues., Dec. 12th.—Great George Street, Westminster, S.W.1, discussion, "The Relative Merits of Methods of Sinking Bridge Foundations," introductory notes—Compressed Air, W. Storey Wilson; Open Brabbing, H. Shirley Smith, 5.30 p.m.

Thurs., Dec. 14th.—MIDLANDS ASSOCIATION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Nottingham and District Flood Protection Scheme," W. H. Haile and Harry Cheetham, 6 p.m.

Institution of Electrical Engineers

To-day, Dec. 8th.—EDUCATION DISCUSSION CIRCLE: Savoy Place, Victoria Embankment, W.C.2, Discussion on "How Best to Introduce the *ab initio* Use of the M.K.S. System to Students," opened by F. T. Chapman, 6 p.m.——SOUTH MIDLAND CENTRE: Birmingham and Midland Institute, Paradise Street, Birmingham, "The Brabazon Aircraft," A. E. Russell, 6.30 p.m.

Sat., Dec. 9th.—N. MIDLAND STUDENTS' SECTION: Yorkshire Electricity Board Offices, Sunbridge Road, Bradford, "The Historical Development of the Induction Type Energy Meter," C. Adamson, 2.30 p.m.

Mon., Dec. 11th.—LONDON STUDENTS' SECTION: Savoy Place, Victoria Embankment, W.C.2, film night, 7 p.m.——N.E. CENTRE: Neville Hall, Westgate Road, Newcastle-on-Tyne, "Distribution Planning of an Area Board," G. O. McLean, 6.15 p.m.

Tues., Dec. 12th.—MEASUREMENTS SECTION: Savoy Place, Victoria Embankment, W.C.2, "The Effect of Friction on the Behaviour of Servo Mechanisms at Creep Speeds," J. G. L. Michel and A. Porter, 5.30 p.m.——N. MIDLAND CENTRE: British Electricity Authority, 1, Whitehall Road, Leeds, 1, "The Phase/Neutral System of Supply for Rural H.V. Distribution," G. T. Garwood and G. J. Websdale, 6.30 p.m.

Wed., Dec. 13th.—SCOTTISH CENTRE: Heriot-Watt College, Edinburgh, "Design of Power Transformers to Withstand Surges Due to Lightning, with Special Reference to a New Type of Winding," A. T. Chadwick, J. M. Ferguson, D. H. Ryder and G. F. Stearn, 7 p.m.——S. MIDLAND STUDENTS' SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Development of Electricity Supply," D. H. Kendon, 6.45 p.m.

Institution of Heating and Ventilating Engineers

Wed., Dec. 13th.—LONDON AND DISTRICT ASSOCIATE MEMBERS AND GRADUATES' SECTION: 178–180, Edgware Road, W.2, "Coal Tar Fuel Firing," E. Brett Davies, 6.30 p.m.

Institution of Locomotive Engineers

Wed., Dec. 13th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, "Electric Traction Prospects for British Railways," S. B. Warder, 5.30 p.m.

Institution of Mechanical Engineers

To-day, Dec. 8th.—Storey's Gate, St. James's Park, S.W.1, "Some Experiments on Tapping," E. Johnson "Screws and Screwing," C. Eatough, 5.30 p.m.——MIDLAND BRANCH: Birmingham and Midland Institute, Paradise Street, Birmingham, "The Brabazon Aircraft," A. E. Russell, 6.30 p.m.

Mon., Dec. 11th.—LUTON A.D. CENTRE: Town Hall, Luton, "The Performance and Weight of Automobile Petrol Engines," Donald Bastow, 7.15 p.m.

Tues., Dec. 12th.—AUTOMOBILE DIVISION: Storey's Gate, St. James's Park, S.W.1, "Post-War Public Service Vehicle Development," T. H. Parkinson, 5.30 p.m.——S. WALES BRANCH: Institute of Engineers, Cardiff, discussion of paper, "The Standardisation of Steam Turbo-Generating Plant," I. V. Robinson, 6 p.m.

Wed., Dec. 13th.—WESTERN BRANCH: College of Technology, Unity Street, Bristol, "The Application of Gas Turbine Technique to Steam Power," J. F. Field, 7 p.m.

Thurs., Dec. 14th.—WESTERN BRANCH: St. Mary's College, Cheltenham, "The Application of Gas Turbine Technique to Steam Power," J. F. Field, 7.30 p.m.

Fri., Dec. 15th.—Storey's Gate, St. James's Park, S.W.1, "Naval Gearing—War Experience and Present Development," J. H. Joughin, 5.30 p.m.——SOUTHERN BRANCH GRADUATES' SECTION: R.A.E. Technical College, Farnborough, "The Development of Armoured Fighting Vehicles Over the Last Twenty-five Years," D. D. Rycroft, 6.30 p.m.

Institution of Production Engineers

To-day, Dec. 8th.—W. WALES SUB-SECTION: Civic Centre, Swansea, "Trends in Coal Production Methods," D. Douglas, 7.30 p.m.

Institution of the Rubber Industry

Mon., Dec. 11th.—James Watt Memorial Institute, Great Charles Street, Birmingham, "The International Rubber Conference at Cleveland, October, 1950," W. J. S. Naunton, 6.45 p.m.

Institution of Structural Engineers

Tues., Dec. 12th.—SCOTTISH BRANCH: Ca'doro Restaurant, Glasgow, "Prestressed Concrete in Engineering Works," A. J. Harris, 6 p.m.

Thurs., Dec. 14th.—11, Upper Belgrave Street, London, S.W.1, "An Investigation of the Strength of Welded Portal Frame Connections: An Investigation of the Strength of Certain Welded Portal Frames in Relation to the Plastic Method of Design," A. W. Hendry, 5.55 p.m.

Institution of Works Managers

To-day, Dec. 8th.—MANCHESTER BRANCH: Grand Hotel, Manchester, "A Business Visit to Australia," G. H. Carnall, 6.30 p.m.

Tues., Dec. 12th.—W. MIDLAND BRANCH: Grand Hotel, Birmingham, "Material Handling," T. Dean, 7 p.m.

Thurs., Dec. 14th.—WEMBLEY SUB-BRANCH: "The Plough," Kenton Road, Kenton, "The Trend of Management," G. Kirk, 12.30 p.m.——TEES-SIDE BRANCH: Vane Arms Hotel, Stockton, "Productivity Teams in America," F. A. Martin, 7.30 p.m.——W. MIDLAND BRANCH: Geisha Cafe, Coventry, "Foremen and their Place Within Industry," 7 p.m.

Junior Institution of Engineers

To-day, Dec. 8th.—39, Victoria Street, S.W.1, "Choice of The Method of Hub Fixing," J. M. Tebby, 6.30 p.m.

Fri., Dec. 15th.—Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "Research and the Marine Engineer," D. J. Hoare, 7.30 p.m.——SHEFFIELD AND DISTRICT SECTION: Grand Hotel, Sheffield, "The Right Spring for Your Job," E. R. Squire, 7.30 p.m.

Liverpool Engineering Society

Wed., Dec. 13th.—24, Dale Street, Liverpool, "Some Aspects of Electrical Marine Propulsion," E. L. N. Towle, 6 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Fri., Dec. 15th.—Neville Hall, Westgate Road, Newcastle-upon-Tyne, "Open Water Test Series with Modern Propeller Forms: Part 3, Two-Bladed and Five-Bladed Propellers; Extension of the Three and Four-Bladed Series," L. Troost, 6.15 p.m.

Reinforced Concrete Association

Wed., Dec. 13th.—Institution of Structural Engineers, 11, Upper Belgrave Street, S.W.1, "The Non-Destructive Testing of Concrete," R. Jones, 6 p.m.

Royal Aeronautical Society

Wed., Dec. 13th.—Technical College, Preston, "Rocket Propulsion and Inter-Planetary Flight," A. V. Cleaver, 7.30 p.m.

Royal Society of Arts

Wed., Dec. 13th.—John Adam Street, Adelphi, W.C.2, "Modern Trends in Spectroscopy," A. C. Menzies, 2.30 p.m.

Society of Chemical Industry

Tues., Dec. 12th.—Burlington House, Piccadilly, London, W.1, "The Development of Catalysts in Industrial Chemistry," Dr. T. Hoog.

Fri., Dec. 15th.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "Aggregate Packing in Road Carpets," J. F. T. Blott, 6 p.m.

Society of Engineers

Fri., Dec. 15th.—17, Victoria Street, London, S.W.1, papers by E. B. Pratt and E. G. Purkis, 6.30 p.m.

Stephenson Locomotive Society

Sat., Dec. 9th.—N.E. AREA: Chemical Club, Loraine Place, Newcastle, Exhibition and Photographic Competition, 6.30 p.m.——LEEDS CENTRE: Y.M.C.A., Albion Place, Leeds, "Locomotive Observation in the 1930s," A. B. Crompton, 2.30 p.m.

Wed., Dec. 13th.—32, Russell Road, Kensington, London, W.14 "The Netherlands Railways," E. J. Tyler, 6.45 p.m.

Stoke-on-Trent Association of Engineers

Wed., Dec. 13th.—Midlands Electricity Board, Back Glebe Street, Stoke, "The Lost Wax Process of Precision Casting," J. S. Turnbull, 7 p.m.